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SPECIAL FEATURES

Table of Contents, Page 27

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TRANSACTIONS
of the
American Society for Steel Treating

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SOCIETY MAKES FURTHER PROGRESS

ANOTHER step in the progress of the American Society for Steel Treating is noted in the announcement that two sectional meetings will be arranged in 1922 in addition to the National Convention and Exhibition. This was a decision reached by the Board of Directors at its last meeting. As announced in greater detail on another page of this issue, the first of these meetings will be known as the Winter Meeting and will be held in New York during January or February, while the second meeting will be known as the Spring Meeting and will be held in Pittsburgh in May. According to present plans the meetings will be short but will be made of considerable value.

These meetings are certain to inspire greater interest in the activities of the Society, coming as they do at convenient intervals between annual metings. As is always the case with national conventions, but a small percentage of the membership finds itself able to attend because of distances to be traveled and the expense attached. The holding of sectional meetings, therefore, will enable a greater portion of the membership to come in contact with activity of the national organization. Members will be able to attend with a minimum of travel and expense. Advantages will therefore accrue to the members and the society at the same time. In a final analysis the strength of a society depends upon the interest of its members and this in turn depends upon what the society has to offer.

Principally the sectional meetings will be of a technical nature, with presentation of papers dealing with heat treating problems of particular interest to the membership located in those sections. Careful thought will be given to the selection of papers and to the authors and the papers will be limited to afford ample discussion. To further promote discussion, it is the intention to preprint the papers in TRANSACTIONS as well to distribute preprint copies. This feature alone should guarantee worthwhile meetings. It is to be hoped that the meetings scheduled for the coming year will be so successful that regular sectional meetings will become institutions in the work of the Society.

TECHNICAL PAPERS TO BE ABSTRACTED

BEGINNING with this issue, TRANSACTIONS has added a new feature, that of the printing of abstracts of heat treating and related papers distributed by technical societies or appearing in the trade and technical press. For some time it has been felt that a section of this nature would be of distinct service to members of the Society. In the preparation of

ELWOOD HAYNES

these abstracts it is not the purpose to review the subjects in any detail but to give sufficient information that the busy reader may be advised of any articles in which he may be interested. Each abstract will give the title of the article, the name of the author, and where the article may be found. As a further time-saver, the abstracts will be properly grouped according to their general nature.

ELWOOD HAYNES ELECTED TO HONORARY MEMBERSHIP

ELWOOD HAYNES, president of the Haynes Automobile Co., and Haynes Stellite Co., Kokomo, Ind., and widely known in automotive and metallurgical fields, was elected to honorary membership in the American Society for Steel Treating at the recent Indianapolis Convention. Probably Mr. Haynes is best known for his building of the first automobile although he has won considerable prominence through his inventions of stellite and stainless steel as well as the introduction of aluminum and nickel steel into automobile design. He was born at Portland, Ind., Oct. 14, 1857. In 1872 he invented an apparatus for making oxygen and succeeded in melting brass, cast iron and high carbon steel, using a furnace and blower of his own construction. He entered Worcester Polytechnic Institute, Worcester, Mass., in 1878 and graduated in 1881, having in the progress of his thesis discovered tungsten chrome steel.

During 1883-84 he was principal of the Portland high school, giving up that work to enter John Hopkins University, Baltimore, Md., where he took a post graduate course in chemistry and biology. From 1886 to 1890 Mr. Haynes was manager of the Portland Natural Gas & Oil Co., Portland, Ind. His first idea of the "horseless carriage" was conceived in 1887. In 1889 he became field superintendent of the Indiana Natural Gas & Oil Co., Chicago, with headquarters at Greentown, Ind. Drawings for the construction of his horseless carriage were made in 1891 and plans for its construction were completed in 1892 at which time he moved to Kokomo, Ind. The first trip in the carriage was made July 4, 1894. The same year Mr. Haynes invented a successful carburetor and the first automobile muffler. Use of aluminum into automobile construction was introduced in 1895 and nickel steel the following year.

An alloy of chromium and nickel containing carbon and silicon was discovered in 1897 and the next year an alloy of pure chromium and pure nickel was formed. In 1899 he made the first 1000-mile automobile trip in America, going from Kokomo to New York City. A rotary valve gas engine was invented and built in 1903. Mr. Haynes in 1906 made his basic invention of stellite for use in table and pocket knives, etc., this alloy being composed of nickel or cobalt with chromium. The basic patent on stellite was obtained in 1907. In 1912 he improved the invention of this alloy to include use in high speed metal cutting tools. Stainless steel, or rustless steel, was invented the same year.

In addition to the American Society for Steel Treating, Mr. Haynes is a member of the Iron and Steel Institute of Great Britain, American Chemical Society, International Congress of Applied Science, Society of Automotive Engineers and the American Institute of Metals.

TWO SECTIONAL MEETINGS ARE ARRANGED

AT THE regular meeting of the Board of Directors of the Society held on Oct. 29, at Cleveland, it was decided that two sectional meetings would be held in 1922 in addition to the regular Convention and Exhibition. The first of these two meetings will be known as the Winter Meeting and will be held in New York during January or February, the exact date to be determined shortly. The second meeting, to be known as the Spring Meeting, is to be held in Pittsburgh in May, the exact date of this meeting also to be announced later. It was the opinion of the Board of Directors and National Officers that these meetings arranged between National Conventions will promote greater activity of the Society, since many members unable to attend the national meetings will be able to attend the sectional meetings. Sessions will be limited to not more than two days and will include consideration of technical papers. A few carefully selected and important papers will be read and ample time will be provided for their discussion. To promote discussion, these papers will be printed in issues of TRANSACTIONS preceding the meetings and in preprint form although due to lack of time this plan may not be completely carried out for the Winter Meeting. It is also announced that a Board of Directors meeting will be held in connection with each of the two meetings.

After considerable discussion concerning the place for the 1922 Convention and Exhibition, the Board selected Detroit. This city was selected for two reasons: First, because it is a central location as far as the membership is concerned; and second, because it is a large heat treating center as a result of the automobile industry. The date for the Convention has been set as Sept. 25 to 30. Another important action of the Board of Directors was that of indefinitely suspending the initiation fee for membership in the Society.

TRANSACTIONS INDEX IS READY

AN INDEX for Vol. I of TRANSACTIONS has been prepared and is now ready for distribution to readers. A copy may be obtained upon request to the National Secretary, 4600 Prospect avenue, Cleveland. It contains the names of 84 authors. For convenience in finding articles, the cross index method has been used, some 300 subjects being listed. To facilitate binding, the index is printed in pamphlet form and the same page size as TRANSACTIONS.

NEW CHAPTER IS ESTABLISHED AT ROCKFORD

THE new chapter of the American Society for Steel Treating established at Rockford, Ill. by the granting of a charter in October is now organized and will hold its opening meeting Monday evening, Dec. 12. The meeting will be held at the Nelson hotel and will be preceded by a dinner. The National Secretary, W. H. Eisenman, will be the guest of the Chapter. A technical paper will be presented at the meeting but the speaker and subject have not been announced.

Two preliminary meetings have already been held for the purpose of organization and election of officers. The officers selected were: Chairman, O. T. Muehlemeyer, metallurgist, Barker-Coleman Co., Rockford, Ill.; vice chairman, O. H. Harrison, Rockford, Ill.; and secretary-treasurer, R. M. Smith, 829 North Court street, Rockford, Ill. The new chapter has made a flying start and has already enrolled over 35 members. Manufacturing interests in Rockford have enlisted their support.

A NOTABLE MOVEMENT IN METALLURGICAL EDUCATION

A DEFINITE educational movement for the benefit of the "man at the fire" is one of the fundamental aims of the American Society for Steel Treating. Not only is this aim stated in the constitution of the society, but the national officers bear this responsibility in mind. This in turn is doubtless due to a constant urge from the membership, voiced through the officers of the 31 local sections, or chapters, so called. All the directors realize that the phenomenal growth of the society has risen from a desire on the part of the skilled heat treater to acquire some technical and theoretical information on his daily work. This desire must not be disappointed; otherwise the decline of the society will be as rapid as its rise.

"A most pretentious effort in educational lines is sponsored by the important chapter at Chicago. Over a year ago it induced the president of Lewis Institute to provide facilities for an evening course in metallurgy, and secured the services of Professor John F. Keller, of Purdue, to direct the work. Several specialists also volunteered to lecture on certain phases of heat treatment. This effort proved such a gratifying success that now two separate courses are offered, one on heat treatment and the other on metallography of iron and steel, each extending over four months, and meeting for three hours two evenings each week.

"Such a program is obviously not beyond the resources of many of our technical colleges, and it appears to be one worthy of imitation. However, other local sections, notably those at Hartford, New York and Bethlehem, did not wait to perfect a working arrangement with some progressive school, but have laid out a well-considered program to occupy the regular monthly meetings, a program which will cover certain branches of the art in a systematic manner, each meeting to be addressed, in not too technical language, by an undoubted authority in his subject. The Hartford chapter demonstrated last year that such a series of meetings was very popular with the members. Knowing that the new president of the society, F. P. Gilligan, is a Hartford man, it is unnecessary to remark that his influence will undoubtedly support those members who desire to perform some service for brothers less fortunate in their technical education.

"Nor should such meetings be devoid of interest to the skillful metallurgist. One has only to read Professor Tyndall's fascinating lectures to know that it is possible to instruct both the expert and the layman. Of course, there are few Tyndalls, but now and then the feat so easy for him, so difficult for others, is attained; witness Dr. John A. Mathews' masterful address recently given in New York on "What Is Steel?" Commonplace facts stated with precision and interpreted with that discrimination which comes unbidden from many years' experience gives not only instruction to the tyro but a new perspective to the specialist."

The above is an editorial which appeared in the Nov. 9 issue of *Chemical & Metallurgical Engineering*, page 858.

ADDRESSES PRESENTED AT THE THIRD ANNUAL CONVENTION BANQUET

ONE of the features of the Third Annual Convention banquet of the American Society for Steel Treating, held at the Claypool hotel, Indianapolis, Sept. 22, was the unusual program of addresses which had been arranged. The speakers were representatives of other large technical societies, however, their subjects of discussion were such as to be of mutual interest to all technical organizations. Dr. Albert Sauveur, professor of metallurgy, Harvard University and honorary member of the American Society for Steel Treating, presided as toastmaster. Professor Sauveur's remarks and the various addresses are printed in part in this article.

TOASTMASTER SAUVEUR: I think in justice to myself I ought to tell you that my task as toastmaster has been made rather difficult. Not being a professional toastmaster, being rather a man of slow wits, it makes the matter a little more difficult. I believe you will agree with me if I say that teachers of applied science have contributed their share to the development of this country. It is therefore appropriate that we should have on our program some professors. Being myself a professor, I feel some hesitancy about this matter. However, I am somewhat relieved at the thought that the gentleman I am going to call on next is more than a professor, he is dean. I am glad, because some people have not a great esteem for professors. And I would give you an instance of that.

There was a gentleman from the South once who found himself in the unfortunate position of having to introduce to the public a colored man, and he said "Of course I didn't want to call him 'Mr.' and I couldn't say 'The D—n Nigger,' so I called him 'Professor.'" Gentlemen, I am going to introduce to you a distinguished mechanical engineer. He is the representative at this meeting of the American Society of Mechanical Engineers, he is a distinguished teacher of mechanical engineering of the old and honored university from which many distinguished engineers have graduated, Dean A. A. Potter, of the engineering schools of Purdue University, Lafayette, Ind., who will speak to us on the subject of "The Engineering Society and Public Service."

Address of Dean A. A. Potter

DEAN POTTER: Mr. Toastmaster, Lt. Col. White, Governor McCray, Mayor Jewett, members and guests of the American Society for Steel Treating. I have the honor of greeting you as a representative of the American Society of Mechanical Engineers.

Now in order to give you some variety in the speaking program, I shall make use of a manuscript, and also for the purpose of giving the reporter an opportunity to discover what makes my inflections so different from those of the other speakers.

I have the honor of greeting you as a representative of the American Society of Mechanical Engineers. This society was founded about 40 years ago for the purpose of promoting the arts and sciences connected with engineering construction. It has at present about 15,000 members who welcome every opportunity to co-operate with other organizations in developing our industries and in adding to knowledge of value to human welfare.

The American Society of Mechanical Engineers is in its aims funda-

mentally educational. It has 39 local sections in different parts of the country and about 50 student branches in the leading engineering colleges and universities. To best serve the specialties of its members, the society has technical sections dealing with power, fuels, ordnance, shop practice, and other branches of mechanical engineering.

Its research committee is a clearing house for engineering investigations and keeps the public in touch with research results, research in progress and research equipment available. This committee has also subcommittees on bearing metals, action of cutting tools, fluid meters, heat transmission, lubrication, accuracy of engineering instruments and vibration stresses of shafting.

The standardization work of the society is concerned at present with the power test codes, the boiler code and the safety codes. The society also co-operates with the American Engineering Standards Committee by recommending standards within the mechanical engineering field.

The activities of the American Society of Mechanical Engineers are not confined to the purely technical questions which are strictly within the professional needs of its members. Much emphasis is placed on service to the community, to the state and to the nation. The society gives considerable attention to problems which affect industry and public welfare. It is being realized more and more that the mechanical engineer is concerned not only with the performance of machines but also with that of men. He is interested in promoting harmonious working of the agencies of capital and of labor. He appreciates that the welfare of the worker is the concern of the public, but knows that human rights and property rights are interdependent; that the security of one depends upon the other.

During these times of unrest, which are too prevalent to be overlooked, it is absolutely necessary that technical societies should take an active and leading part in properly guiding public opinion. We cannot expect the return of prosperity unless our people are interested in eliminating class consciousness and mob control. We must develop in the public mind a more tolerant attitude toward the development of our national resources, transportation and manufacturing under private control.

Technical societies such as the American Society for Steel Treating and the American Society of Mechanical Engineers should co-operate in solving problems of interest to industry and humanity. They should also take an active interest in the education of men for industry and should give encouragement to technical research.

Modern industrial conditions have resulted in a greater realization than ever before of the value of technical education and of industrial research. Engineering educational institutions on the other hand are recognizing their opportunity for service in connection with the problems of industry and feel that such a point of contact makes their instruction and their experimental work more practical and more useful.

Our technical universities to best serve industry should accomplish two things: First, they should produce through their resident instruction thinking men who can handle human as well as material problems. This can be accomplished only if the greatest emphasis is laid on the teaching of men and not of subjects, if the instruction is based upon each student's ability, knowledge and experience, and if every effort is made to develop in each student initiative, judgment, co-operative ability, sense of responsibility and the other personal qualities so essential in industry.

All engineering instruction should not be limited to the purely technical phases of design, construction and operation, but more attention should be given to develop men who can also handle the administrative and financial phases of industry.

The second function of a technical university is to carry on investigations and experiments of value to industry and to the public. Research goes hand in hand with good teaching, as a person receives his greatest development if he learns to take new paths instead of remaining in a rut. We are living in an age which places a premium on initiative, the power to take the lead, to plan, to originate. To develop leaders for industry we must not limit our training to the past, but we must instill in our students the desire to take new paths, to try new experiments, to look ahead and to develop the power of initiative. Industrial research carried on at our laboratories is of value in stimulating the students to become leaders in the search for nature's truths.

It is a well known fact that industrial research has been until recently greatly neglected in the United States. We were fortunate in having such genius among our people, but we have given too little attention to development of fundamental truths. The United States with 6 per cent of the world's population is responsible for over two-thirds of the epoch making invention of the past century. The telephone, the telegraph, the typewriter, the cash register, the adding machine, the incandescent lamp, the talking machine, the electric furnace and the movie are only a few of our great inventions. The great natural resources of this country have enabled us to supply two-thirds of the world's supply of oil, copper and aluminum, nearly half of the world's supply of coal, zinc, iron, steel and lead and more than one-fifth of the world's supply of gold. Our progress and accomplishments of the future will be even greater than they have been in the past if we pay greater attention to research.

It is hoped that in the near future when the business of the country improves, societies such as the American Society for Steel Treating will find it possible to encourage research at technical universities by establishing industrial fellowships and research professorships. Your society can at present best aid technical education by appointing visiting committees, similar to those established by the American Railway Engineering Association, and for the purpose of advising our engineering colleges concerning lines of study and research in connection with steel treating.

With reference to the last statement, the American Railway Engineering Association has visiting committees that make an inspection of the equipment and the work of half a thousand or so institutions distributed in different parts of the country, and I can say that those committees have been a great stimulus to the work of Purdue University. Again, I beg to extend you greeting on behalf of the American Society of Mechanical Engineers.

TOASTMASTER SAUVEUR: Dean Potter has told us things worth hearing and things with which we in the main, at least, are sympathetic. It is only this morning that I knew of the next speaker I am going to call upon. I didn't even have time to look into "Who's Who." Fortunately, I know him very well; he is one of my colleagues of Harvard University, and I hope I may say that he is one of my friends. I know

many things about him, all good things. I know that he is a very distinguished electrical engineer, that he is a distinguished teacher of that subject; I know that as chairman of the welding committee, as chairman of the Engineering Division of the National Research Council, as chairman of the engineering standards committee, and probably as chairman of other committees, he has rendered a service to the engineering profession and to the country of a very high order. I take great pleasure in calling on Professor C. A. Adams.

Address of Prof. C. A. Adams

PROFESSOR ADAMS: Mr. Toastmaster, ladies and gentlemen: I wish to apologize for taking a subject which is not on the program, a subject which I sent in when I was first notified of the desire to have me speak this evening. After I sent that subject in your President asked me if I would talk on the "National Aspects of Research" or at least make some reference thereto. But I had to write him and tell him that I had promised to make an address on that same subject at one of your meetings, so the real subject of my talk this evening is "The Spirit of Research in Engineering and Industry."

Some years ago I had a very excellent lesson. I had prepared a highly technical paper for the American Institute of Electrical Engineers. It came at the end of a long session and everybody wanted to get away. I got up and stated the substance of the paper in two sentences—short sentences—and said that anybody who wanted to get the information, the technical information, therein could read it, and sat down. I received great applause and two or three highly commendatory remarks from the presiding officer and others, and was led to feel that I had done a great job. Afterwards, in thinking it over, when my pride cooled down a little bit, I came to realize since that the reason for the rejoicing and the complimentary remarks was that I had released the company without a long harangue. Therefore, in order to be sure that I might not subject you to a long harangue, I have written out my comparatively brief remarks, which I will read to you.

Incidentally, I am going to criticise my own profession of teaching, and the engineering profession as well, and if the metallurgists and those of you here who are interested in research are not open to this criticism, I hope you will not take it unto yourselves, because I am not a metallurgist, and am not so familiar with the conditions in your profession as I am with those in the engineering profession.

Our conception as to what constitutes research, as well as to the value of research to the industries of the country depends so much upon our training and experience, that it may be well to start by presenting to you a picture of the relations between science and industry, which has been gradually developing more and more clearly in my mind during 30 years of endeavor in which the major interest has been the application of science to the solution of industrial problems.

On the one hand we have the reservoir of scientific knowledge, the result of centuries of patient research by the world's great scientists; and on the other hand industry, brought to its present state of evolution for the most part by practical men employing largely empirical methods The exceptions to this statement in some cases are striking but not numerous; and even in these exceptional cases the use of scientific knowledge and scientific method is of recent date. Moreover, in most

of these cases the extent of the application is as yet exceedingly limited.

Thus it is not stretching the facts to indicate in our picture a considerable gap between science on the one hand and industry as a whole on the other. In this gap stands the engineer, but unfortunately for industry he fails to bridge the gap, except in a few exceptional cases. As this is a vital part of my picture and also an important part of the foundation for the message which I hope to convey to you at this time, I am going to risk boring you and perhaps shocking you by giving you my reasons for this statement. My conviction on this point is the result of 30 years of teaching engineering combined with an unusually extensive contact with industry. If the statements I make seem somewhat emphatic, I ask your indulgence, but beg you to believe that I can support them with ample evidence.

Our engineering education is grossly superficial. Students are taught to do typical tasks or to solve typical problems by orthodox or established methods which are almost invariably approximate. They think that they are employing scientifically exact methods. They are taught the language of the profession by rote without any understanding of the reason why. They are crammed with information, but have no grounding in the elements of the sciences underlying their profession. Their memories are trained but not their power of analysis. They are not encouraged to make the subject their own or prepared to solve new problems. In short, they are not taught to think or to know when their starting point in analysis is sound or fundamental. In support of these statements I could recite illustrations by the hour, taken not so much from my teaching experience as from my contact with engineers in practice, many of them considered experts in their own fields.

Please do not think that I am setting before you an unreasonable or academic ideal; I know what can be done with average good raw human material; I know what is sadly needed in many of our industries and I know that many important problems could be solved easily by engineers with a sound fundamental training, even if they knew a little less about the so-called practical side of their profession. Neither have I in mind only the so-called research engineer. Every engineer should have the spirit of research, should be trained to scrutinize evidence of fact, to make sure of his foundation and to build up his analysis carefully and sure-footedly on that foundation. In other words, he should be something more than a machine, performing an operation just as it has been performed by many others before. Otherwise he is not an engineer worthy of the name.

In fact my creed is that this spirit of research should extend even farther down the line to the more humble employes, that they should be encouraged to understand a little of the reason why of their work, to think about it intelligently and to strive for improvements. This would not only make them more efficient but would also tend to make them more contented in their work and might aid materially in the solution of some of our troublesome labor problems.

To return to our picture of science and industry with the gap between, a few of our large corporations, realizing the value of bridging the gap, of tapping the reservoir of scientific knowledge and of applying this knowledge to the solution of their industrial problems, have established great research laboratories, officered not by engineers but for the most part by scientists. The annual operating costs of these laboratories

range from a few hundred thousands to $10,000,000, but the calculable savings, disregarding those benefits to the corporations as well as to the consuming public, which cannot be figured in dollars and cents, range from five to ten times the cost. No other expenditure yields anything like this return, and the accounts of some of the accomplishments of these research laboratories read like the story of "Alladin's Lamp."

But the research departments attack only those problems brought to them; there are numerous other possibilities for improvement never presented, because the engineers in charge of the work in question do not see the possibilities. This again is where the research spirit would count. In many cases the improvement could be made by the department concerned without even referring it to the research department. In other words, it is quite as essential to see the opportunity for improvement as to be able to make it. In fact, the second step cannot be taken without the first, and the first will not be taken unless the knowedge of fundamental science and the habit of analysis, that is, the research spirit, is present at the source.

Thus although industry is beginning to wake up to the importance of science and research, most of our industries have as yet only scratched the ground, and even in those few cases where great research departments have been established, they fall short of the possibilities owing to the lack of the research spirit throughout the engineering staffs of the various departments.

All of this may seem to be a serious reflection upon the teaching profession and in some degree it is; but the fault is shared by the employers of our young engineers. In the early days they criticized the training of the young graduates as too theoretical, and demanded a more practical training. In the attempt to meet this demand, to familiarize the student with the lingo of his profession, to so train him that he would be able to step into a plant and make a good showing the first month, our engineering schools have so seriously slighted or slurred over the fundamentals that the young graduate frequently has no real understanding of the elementary or fundamental phenomena that have to do with his every day work. Our engineering training has never been too theoretical, that cannot be; the real defect is that the student hasn't a sufficiently sound grasp of the theory or science of his profession; if he had he could apply it easily enough, and not according to the machine-like unintelligent method of the real engineer who had made the subject his own and is master of the situation; in short, who has acquired the research spirit and can help to bridge the gap between science and industry.

That this gap needs bridging is hardly open to argument before this audience. There is ample evidence to show that because of this gap, many of our industries are still a generation or two behind the underlying sciences, and that great improvements could be made by the application of available scientific knowledge and of scientific method.

Two things are essential to the advance in industry which every society of this kind was organized to promote: First; The spread of the spirit of research, that is the desire to know the reason why, the habit of scrutinizing evidence of fact, and of clean sure-footed reasoning on the resulting foundation; and second; the extension of our scientific knowledge, that is, a more accurate and more comprehensive knowledge of physical and chemical constants and of the properties of materials.

But the first of these is of prime importance, since success in the second is dependent thereon. Hence my plea to you is for the encouragement and spread of the spirit of research.

TOASTMASTER SAUVEUR: As a professor of metallurgy, I wish that I could claim that the shortcomings which Professor Adams has called to our attention in the teaching of engineering do not apply to the teaching of metallurgy. I feel, however, that we must admit that we come within the field outlined, and we must hope that reforms in the direction which he has indicated will come.

We who are interested in the heat treating of steels realize how much the automobile industry has done to advance the art of treating steels, acting in the nature of a club to their vision and to their encouragement of research. It is therefore fitting that we should have as a speaker a representative of that great industry, and we are fortunate tonight in having with us a man who can talk with authority on any subject pertaining to the construction of automobiles, a man who has contributed much to that field, a man who is instructor of engineering of the University of Michigan, a member of the Naval Advisory Board, and the official representative at this meeting of the Society of Automotive Engineers, Howard E. Coffin, vice president and consulting engineer of the Hudson Motor Car Co., Detroit.

Address of Howard E. Coffin

MR. COFFIN: Mr. Toastmaster, Governor McCray, Members of the Society, ladies and gentlemen: Like most of the rest of you, I suppose, I am a member of a half dozen other engineering organizations, but I have yet to see one of them that, on its third birthday, has been able to put up such a performance as this has been. In looking over the program I see that this is your third banquet. I am wondering what your tenth or eleventh or twelfth will be, if you keep going at this rate. I also notice from the program a happy little selection in the Secretary for a heat treating society, if I am correct in the translation of the name "Eisenman."

I think that if the lantern performs as it should that there will be some very much more interesting things for you than anything that I might say to you, but I cannot help taking a few minutes to just touch perhaps upon one or two things.

The last time I spoke in this room was to a gathering considerably larger than this, as I remember it, in 1916, when some of us were frantically urging that the country prepare for war, even in the face of a political campaign that "he kept us out of war." At that time we were urging an industrial organization for the defense of the country. We were busy, the engineers of the country were busy, particularly those of the five Founders' Societies of the organizations in taking an industrial inventory of the production resources of the country. The steps in this compaign were a survey of the country's producing capacity and its classification and an educational program on the part of the government through the placing of provisional or educational orders throughout the country for munitions, thus building up a nucleus for a munition making capacity; and third, the enrollment of the skilled labor of the country in an industrial reserve.

As you all know, the inventory was taken, legislation was enacted

permitting of the placing of educational orders without the usual legal necessity of a low bid, to the extent of $50,000 each. The program of actual placing of educational orders was about to be launched when we broke off negotiations with Germany, and of course all plans were lost in the chaotic preparation attendant upon our entry into the war.

We had already obtained also the support of the organized labor unions behind the idea of enrollment of the skilled labor of the country in industrial reserve. This program was launched, as you will remember, upon the basis that if this country were to have any continuing form of preparation for defense, it must have as its absolute foundation an industrial organization linked closely with the governmental departments in Washington.

I cannot help touching for a moment upon our actual experience. When war was declared, because of the lack of just such a contact between the war-making machinery of the government and the industrial machinery of the country actually months intervened before contracts were placed by the government for even the most essential articles of war, such items as machine guns, ordnance, rifles, airplanes, and tanks. They were not ordered until from six to nine months after the declaration of war; and as a direct result of another lack of industrial preparedness, if I may use that term, the United States at no time during its participation, the 18 months of its participation in the war, ever supported a single division of an army on the fighting front in any such way that it could have defended itself or inflicted serious loss on an enemy.

That may seem like a pretty serious arraignment of the industrial capacity of a quantity production country, of a country that has prided itself on its ability in quantity production. In fact, General Hahn, in visiting Detroit only a short time ago, and being entertained at breakfast by a group of engineers, made the statement, he having been in Europe practically all of the time, and perhaps not seeing at close range some of the problems on this side, that "You fellows in the industrial side of the job messed things up terribly during the war, but we are organizing the general staff of the army now upon a basis that will prevent this ever being repeated. We are going to train members of the general staff in the various industries of the country and immediately upon declaration of another war, we are going to put the general staff in complete charge of the whole show."

Now if any of you gentlemen had anything to do with those people, with the dyed-in-the-wool army officer, in the early days of the war, I think that your expression will be "My God!" Simply to make a long story short, in connection with the industrial side of the proposition, we learned during the war that it took us about three or four times as long to make a gun with which a man could shoot as it did to teach the man to shoot it. In short, the question of personnel, although we delayed until September before we began to organize an army seriously, some three or four months after we ought to have been equipped, we had two million or more men in France and some other millions in this country pretty well trained and were in position to give a very good account of ourselves insofar as the matter of personnel went. But we were never at any stage of the game during our participation in the war able to give an account of ourselves on the munition producing standpoint, and for just one great reason, or perhaps I had best divide it into two. One

was that on the declaration of war there was no organization or no individual in Washington who had the slightest idea about either what the army needed or how to make it. There were no proper specifications or drawings in existence for practically any article of munition equipment, and it was many times months after contracts were placed before the proper specifications and drawings were supplied to the manufacturer. It was usually other months before the governmental representatives and the industrial men got together as to what the thing ought to look like when it was finished.

Therefore, it seems that the one outstanding lesson of the war ought to be that if we are to have any degree of preparedness,—and, mind you, the very cheapest form of preparedness,—there must be established in peace time a contractural relation between the war-making machinery of the government and the individual manufacturers as the producers of war materials. In short, if the Nordyke & Marmon Co. here in your own city could have in its files a statement from the war department that its equipment had been analyzed and that in the event of war it would be called upon to make, say 6-inch shell cases, and if it could have in its files a complete set of specifications and drawings covering that article, and if in its business department it had a contract, a provisional contract with the government agreeing that within 60 or 90 days after a declaration of war that concern would be producing 2000 of those shell cases per day,—two things would result. In the first place, the Nordyke & Marmon Co. would study the job, they would know what they were going to do, and you can bank on it that there would be a trained nucleus within that organization capable of taking hold of the job upon a moment's notice.

The other thing would be even more important. The moment the contract was placed with the Nordyke & Marmon Co. it would begin to hammer the war department for the specifications and drawings to accompany that contract, and for a full knowledge of the facts as to the tests and treatments which those articles were to go through. In self-defense the war department would be forced to prepare and to keep on hand the specifications and drawings covering this job.

No amount of patriotic oratory, no amount of voting of thumbs by congress in the house or in the senate for a large army or a large navy will ever bridge the first 12 months of the entry of this country into a war. We poured out money like water when we finally got into the war, but we didn't gain one moment of time, and if we are engaged in another war 10 years from now, unless we adopt some continuing system of industrial preparation along the lines that I have outlined, we will pay the same old price in money, time and lives. And we may not have, when that time comes, five or six or eight or ten million other men, or thousands of other factories carrying the load and fighting our fight until we take our time in getting ready.

I was going to talk to you something about the aircraft situation and about the policies of our country and about the necessity for certain legislative action. I will only touch briefly on that. I have here with me some slides and films made in connection with various aircraft activities, particularly the sinking of the German battleships off the Virginia Capes. I think that you would be very much more interested in those, and it will be much more instructive to you than to listen to anything that I might say along any lines of the subject.

I cannot help pointing out to you, however, a few of the things that

have happened. In 1914 the airplane was viewed on the front as a joke. No one had any confidence in its ability to do anything worthy of note in connection with the war. Finally a few observations were made of, for instance, the German column moving through Belgium, by a scattered few French planes. Planes were used once or twice in connection with the battle of the Marne and military leaders began to see the necessities and the possibilities for observation purposes. No one thought of arming or armoring a plane or using it in any other capacity. Finally some bright aviator carried a revolver, then someone took a rifle, someone then mounted a shot gun and then they had a bright idea they could mount a machine gun on a plane. That was in 1914. Planes they were using weighed a couple of thousand pounds. Everyone said that unless they were made as light as air it would be impossible to use them anyway. In 1918, not so very long afterward, they were using planes weighing 30,000 pounds; they were armored, they carried cannon up to approximately 2-inch bore, carried machine guns, four, five or six of them, crews of 8 or 10 men. During the battle of St. Mihiel our General Mitchell was in command of the largest air force ever gathered, made up of Americans, British, French--1500 active planes. They were sending over in flights for attacking the Germans 300 to 350 planes in a flight, dropping thousands of pounds of high explosive, flying low, using machine guns, in every way harrassing the enemy. It is a pretty safe bet if the war had gone on another six months at the rate we were building Liberty engines, at the rate we were supplying them to the Allies, or fitting their planes up, the absolute mastery of the air would have lain with the Allies. In fact, it practically did at the time the armistice was signed, and while the infantry, of course, and the big guns would have gone on hammering the line, there is no doubt at all but that the decisive element in the war would have been the air service.

Now that sounds like a rank heresy, I know, but there have been so many occasions for making statements which have sounded like rank heresy, and then see them come true, that I feel perfectly safe in doing it.

You will remember that it was only about six months ago that a great many people down in Washington were busy explaining that it would be impossible for a battleship, or practically a ship of any kind, to be sunk from the air. I only need point out to you that now these same gentlemen are busy trying to find some way to prevent a battleship being sunk from the air, because it looks as if there is not now, and probably never will again be a battleship built that cannot be sunk from the air. That is just an indication of what we may expect in that line.

The heaviest bombs used in sinking the Ostfriesland which you will see on the films tonight were 2000-pound bombs, about 1000 to 1100 pounds of high explosive and the rest made up of shell casing. The greatest planes that we have now are capable of carrying only one or two of these bombs. Six of them were dropped on the Ostfriesland during the first 19 minutes of the test and although the official reports were given as 24 minutes, we who held our watches on the job know positively it was but 19 minutes before the big battleship of 20,000 tons, and the pride of the German navy, turned turtle and sank. As a matter of fact, only three or four of the bombs were necessary. The others were dropped merely as parting salutes. None of these shells hit the ship. A very canny provision had been introduced into the arrangements to the effect that the air service of the army should be permitted to make

only two direct hits. Consequently, General Mitchell's orders to his fliers were to make no direct hits, in short, to put the bombs in the water alongside the ship, as being the safest and most certain way of sinking her. The results of all the tests off the Virginia Capes have gone to show that an actual hit on an armored ship, with her armored decks, does little more than local damage insofar as removing the anti-aircraft defenses and the personnel are concerned.

As to just what effect these bombs would have upon living personnel on the ship was not, of course, determined in these tests, so this week a repetition of the tests is being made, not only using high explosives, but poison gas shells, with goats and other animals tied in all the various parts of the ship so that between the tests the boards of observation may go aboard and determine the probable effect upon human life.

I can point out to you, too, that although the largest bombs used in these tests were 2000 pounds, a good many of us are invited down on Oct. 8 to see the dropping by the army ordnance department of the 4000-pound bombs. All of the bombing planes used in these recent tests were known as the light bombers. The new heavy bombers will carry two of the 4000 pound bombs.

It is interesting also to know that there is now under construction for the government, planes of as high as 3500 and 3600 horsepower, made up of three groups each of 400-horsepower Liberty engines, geared to propellers nearly 20 feet in diameter. Those of you who heard the talk this morning of the representative of the chemical warfare division and who realize that in the wars of the future poison gas of all the various varieties will probably make a much greater impression and play a much greater part than in the last war, you can see readily what the probable result of these weight carrying craft of the air will be.

I don't want to leave with you the impression that the airplane has spelled the finish of the battleship. That is not true. Our protective plans of the future must be based upon what may be termed a "three plan navy." No fleet can exist in the future without adequate aircraft protection, and, on the other hand, we don't know now of any aircraft activity other than the carrying of planes upon carriers which will themselves need protection of the battleship type; we don't know of any means in the air alone in which we could carry war into distant territory. Airplanes, of course, are limited in their radius. Therefore, we must carry the base with them. The only way to do that is through adequate equipment of aircraft carriers, and the protection of those carriers by the other arms of the naval service. This may bring us, of course, to a greater percentage of high-speed, heavily-armed, but not so heavily armored, cruisers, and it may bring changes in our battleship program. The relation of the capital ship, so-called, the armored ship, to the higher speed cruiser and submarine destroyer, etc., may be changed, but the capital ship will not be entirely eliminated from our program.

The only way, of course, in which the United States can possibly build up an adequate protection in the air is through the development of commercial aviation. The only way that we were able to arrange transport to our troops and for our supplies in the late war, was through a motor car and truck industry which has been built up in peace times through commercial demand. We must do the same thing in the air.

There is one great stumbling block to commercial aviation, exem-

plified by the headlines which you read in the newspapers almost every day. You always see an account at first of airplane accidents; you never see an account of the successful flights. During the last year some 6,000,000 miles have been flown in this country alone, and about 225,000 to 250,000 people transported, and with practically a negligible ratio of serious accidents. But you never hear of those things. You hear only of the terrible accidents.

The one great reason for accidents in this country is that we have dilly-dallied ever since the Armistice, and have not passed one single national law governing our aviators. There is not a law that will prevent any of you from going out and flying anything that you may find in your neighborhood that in any way resembles an airplane. You can go up to 10,000 feet and fly anywhere on earth your heart desires, and there is not a single penalty provided—no provision that the plane must be inspected, no control after it is in the air, and yet if any of you have come up in the elevator tonight you probably noticed the inspection certificate staring you in the face. But if you go up to 10,000 feet and have an accident, no one is blamed, no one is prosecuted, no one inspects the machine or seems to care what happened.

The American Bar Association has been playing with the situation for two years, until it has got to be a favorite indoor sport with them. And they have finally determined that their constitutional limitations will probably prevent the United States government from assuming control of the air. There are many constitutional questions raised,—do you own the property 10 feet above the land you buy, 50 feet, or 5,000 feet, or what is the limit, if any? Moreover, each state is supposed to be jealous of its authority and to resent any action on the part of the federal government to extend its jurisdiction over the state line.

During the last few weeks, I have just heard, as chairman of a committee representing the underwriters of various aircraft interests, of the drafting of a bill which was introduced by Senator Wadsworth in which it is hoped that we will overcome the objections brought up by our more technically advised lawyer friends. We have based this bill upon the provision that while we cannot take control of the air within a state without a constitutional amendment, that the United States government does control the post roads, and every government building and interstate commerce, so we have provided that just so soon as a plane goes into the air and so soon as it crosses over any post road, it becomes amenable to government control. I think that our lawyer friends are almost making up their minds to get behind this bill and push it as a short cut to the desired end. That is the Wadsworth Bill which has just been introduced, and if there is any one thing that you can do to further the cause of aeronautics of this country, it is to push this bid through, creating a department of civil aeronautics within the department of commerce, under Herbert Hoover. Let's get some laws and regulations governing this department and its developments. Canada has done it, and has practically eliminated accidents. She has a large number of air laws within the state. Great Britain has done it, as have France and Italy, and it is up to us to get in line as rapidly as possible.

TOASTMASTER SAUVEUR: I am going to give the floor to Mr. Eisenman for a few minutes as he has a communication to read.

SECRETARY EISENMAN: Mr. Toastmaster, Governor McCray, Mayor Jewett, ladies and gentlemen. The Secretary has upon his desk a

communication from Ferdinand Barnickol, president of the American Drop Forge Association, in which he expresses his regret at his inability to be present tonight and sends his best wishes for the further growth and success of the American Society for Steel Treating. Mr. Barnickol's letter is as follows:

Remarks of Ferdinand Barnickol

After attending one of the meetings of your Society this week, I was impressed with the problems that are common to both your Society and the American Drop Forge Association, which I have the honor to represent, and I was reminded of a story that appeared in a local paper this week.

A president of an Indiana Farm Association was addressing a convention of another organization, and in discussing common problems, he recalled the case of the farmers of an Indiana community, who years ago organized themselves into a secret society, with the slogan—"We plow, we sow, we reap", as the pass words to the lodge room. The lodge room also was used on other nights by a newly fledged Commercial Club. One night a farmer climbed the stairs and spoke through the keyhole: "We plow, we sow, we reap".

"Go to h—l, you Hayseed", bawled out a voice from within. The farmer, abashed, hurried downstairs and told a brother farmer what had happened. The other replied: "Good gracious, this is the Commercial Club's meeting night. You've given away our pass word."

"Oh well", said the farmer, "I got theirs."

So with the American Drop Forge Association. It has learned your Society's pass word and it had nothing but praise for the evidences of useful activity and pronounced accomplishment of your organization. Your president in his opening address at the convention accorded to fellow officers and directors large credit for the effective work which has been done during the past year, but we, who have closely observed the development of the Society, will unstintingly extend to him our congratulations for the able manner in which he has directed his associates with the result that the American Society for Steel Treating has gained more prestige and enduring strength than any organization in the metal or engineering trades, in a similar space of time.

Lt. Col. White has unselfishly devoted his energies toward building up this organization, with the sole desire to gain through education and research, a development far reaching in its beneficial effects wherever steel and other metals are used. The painstaking efforts and the great devotion to his work will make their impress on succeeding administrations, and the foundation he has laid for the future development of the Society's work, will endure for years to come, if the Society on the whole will be guided by the example of Col. White's conception of duty and intelligent endeavor, and if it will keep in mind the fruition of his unselfish enterprise.

I beg to state on behalf of the American Drop Forge Association, that our Association has been a close observer of the American Society for Steel Treating activities, for the forging industry naturally is greatly benefited by the development of the art to which your Society is so ardently devoted, and it feels that the interests of these two organizations are so common, that it wishes to fraternize with you to the fullest

degree, and to lend its support in the further advancement of the principles and ideals, laid down by your able retiring President, Lt. Col. White.

The American Drop Forge Association extends its greetings to the American Society for Steel Treating and congratulates the membership on the faithful support it has extended to its officers as evidenced through the unusually large attendance at your convention this week and the intense interest shown in the convention proceedings.

OBITUARY

DIMITRI KONSTANTINOVITCH TSCHERNOFF, prominent Russian metallurgist and professor, died Jan. 2, 1921, according to an announcement received recently by Col. A. I. Krynitzky, associate physicist of the Bureau of Standards, Washington, and a close friend of the deceased. A brief history of his life has been supplied by Colonel Krynitzky. Professor Tschernoff was born in Petrograd, Russia, Nov. 1, 1839, and received his higher education at the Technologic Institute, later attending the University of Petrograd. In 1866 he entered the employ of the Obouchoff steel plant where steel guns were manufactured. It was in this period of his life when he did the most important work on the heat treatment of steel, its crytallization and metallography. In 1880 he left the Obouchoff plant and went to the south of European Russia where he discovered and developed some rock salt mines, this enterprise bringing him a rather large fortune. He returned to Petrograd in 1884 and after holding several governmental positions, was engaged as professor of metallurgy in the Michael Artillery Academy, where he remained until the Russian Revolution. After spending his vacation in Yalta, Crimea, in 1917, the revolution prevented his return to Petrograd. Overcome by poverty as a result of the existing conditions, his health broke down and he died Jan. 2, 1921. Professor Tschernoff's works in the metallurgical field are well known to students of metallurgy. A good abstract of his most important papers was published in the *Revue de Metallurgie*, 1915, pages 829-62, in commemoration of his seventy-fifth birthday.

THE METALLOGRAPHY OF HIGH SPEED STEEL

By J. P. Gill and L. D. Bowman

FUTURE developments in the quality of high speed steel might be expected not so much in analysis as in methods of manufacture, thus the study of the constitution of high speed steel has become fundamental if the highest quality and most uniform product is to be obtained. How many men have had the experience of two pieces of high speed steel of the same analysis and supposedly of the same heat treatment, where one piece gave results much better than the other on the same job? Why? Surely there is a reason. And that reason undoubtedly is enclosed in the history of those pieces of steel, for it is their history that determines their quality; and a study of their history is a study of their constitution.

The use of the words "high speed steel" in this paper refer to a steel of an approximate analysis as follows:

	Per cent
Carbon	0.65—0.70
Tungsten	17.50—18.50
Chrome	3.75— 4.15
Vanadium	0.90— 1.25

This analysis is recognized as the analysis of the first quality high speed steels. Moreover, when reference is made to the ingot or billet, etc., it infers high speed steel.

The word metallography used in the title of this paper, "The Metallography of High Speed Steel" is used in its broader sense; under this title we are including the critical points and constitution of high speed steel with a discussion of whatever experiments and factors that bear a direct relation to these two subjects.

There have been but few systematic investigations made on the subject of the constitution of high speed steel, although there has been a reasonably large number of investigations made on the transformation points, the hardening and drawing temperatures, efficiencies of various analysis, uses, magnetic properties, etc. A paper presented by Honda and Murakami[1] at the Iron and Steel Institute, in May, 1920, represents probably the best that has been written on the constitution of high speed steel and is worthy of consideration in detail, but some of the statements they make are but feebly supported by the evidence they present. Their experiments consisted essentially of a study of three series of high speed steels, the first in which the percentages of tungsten and chromium were constant with the percentage of carbon as a variable, the second with the percentages of tungsten and carbon constant with the percentage of chromium as a variable, and the third with the percentages of chromium and carbon constant with the percentage of tungsten as a variable. Honda has deduced most of his changes in structure in heating and cooling by magnetic analysis. A steel containing 0.62 per cent carbon. 5.12 per cent chromium and 17.20 per cent tungsten is taken as a typical example and in the normal condition he states that this steel is composed

1. Journal Iron and Steel Institute, 1920, No. 1, Vol. CI, p. 647.

A paper presented at the Indianapolis Convention. The authors, J. P. Gill and L. D. Bowman, are metallurgists, Vanadium-Alloys Steel Co., Latrobe, Pa.

of iron-dissolving tungstide, free tungstide, chromium carbide and tungsten carbide all in a free state.

Here is shown the manner in which they would write this structural constitution:

$$[(Fe) + (Fe_2W)] + [Fe_2W] + [Cr_4C] + [WC] \quad (1)$$

Above the Ac1-3 point both carbides dissolve in the austenite and then the constitution is thus:

$$[Fe_2W] + [(Fe) + (Fe_2W) + (Cr_4C) + (WC)] \quad (2)$$

The constituents in solid solution are enclosed by parenthesis and those in a free state by brackets. As the temperature increases above the Ac1 point, the chromium carbide dissociates as follows:

$$2Cr_4C = Cr_3C_4 + 5Cr \quad (3)$$

Then as the affinity of carbon for chromium seems to be stronger than its affinity for tungsten, some of the chromium produced by the dissociation of Cr_4C will react on the tungsten carbide as follows:

$$3Cr + 2WC + 4Fe = Cr_3C_2 + 2Fe_2W \quad (4)$$

hence at the higher temperatures the structure is

$$[Fe_2W] + [(Fe) + (Fe_2W) + (Cr) = (Cr_3C_2) + (WC)] \quad (5)$$

But cooling from the temperature at which this structure exists, the lowering of the transformation point is caused by the presence of dissolved carbide Cr_3C_2 in austenite containing chromium and tungstide, thus the steel cooled to normal temperatures has the same constitutional structure that existed at the high temperatures, that is

$$[Fe_2W] + [(Fe) + (Fe_2W) + (Cr) = (Cr_3C_2) + (WC)] \quad (5)$$

If the steel be now heated again the dissolved carbides separate and the reactions (3) and (4) proceed from right to left and (Cr_4C) and WC are again formed.

To substantiate these views, Honda says further: "First, in the magnetic analysis, the chromium effects the lowering of transformation in the presence of carbon, and if the carbon content is 0.6 per cent, about 3 per cent of chromium is sufficient for the lowering or the self-hardening; a further addition of chromium not being effective, unless the carbon content is increased. Second, the resistance to tempering of hardened steels depends on dissolved Cr_3C_2 and tungstide in iron containing chromium as in the steels of Series II where the percentages of chromium is the variable; as the percentage of chromium increases to 3.32 per cent, the maximum increase of magnetization at the range of 400 degrees Cent. gradually decreases and that of 700 degrees Cent. increases, but a further increase of chromium has no effect. While in steels of Series I, with the percentage of carbon as a variable, as the carbon content increases from 0.57 to 1 per cent, the maximum increase of magnetization at 700 degrees Cent. becomes less, showing that the resistance to tempering increases. Third, that the maximum increase of magnetization at about 700 degrees Cent. due to tempering at first increases as the maximum temperature of previous heating increases from Ac1 point to 1000 degrees Cent., but decreases as the temperature further increases. This would show that if the maximum temperature of previous heating is below 1000 degrees Cent., the quantity of the dissolved carbide Cr_3C_2 is very small and slowly increases with the rise in temperature and thus by tempering, the separation of the carbide slowly increases. Fourth, that in chromium steels without tungsten there exists at high temperatures some dissociated chromium and Cr_3C_2 as shown by the lowering of the transformation by a quick cooling from 900 degrees Cent., but as tungsten is added to the steel some tungstide is formed

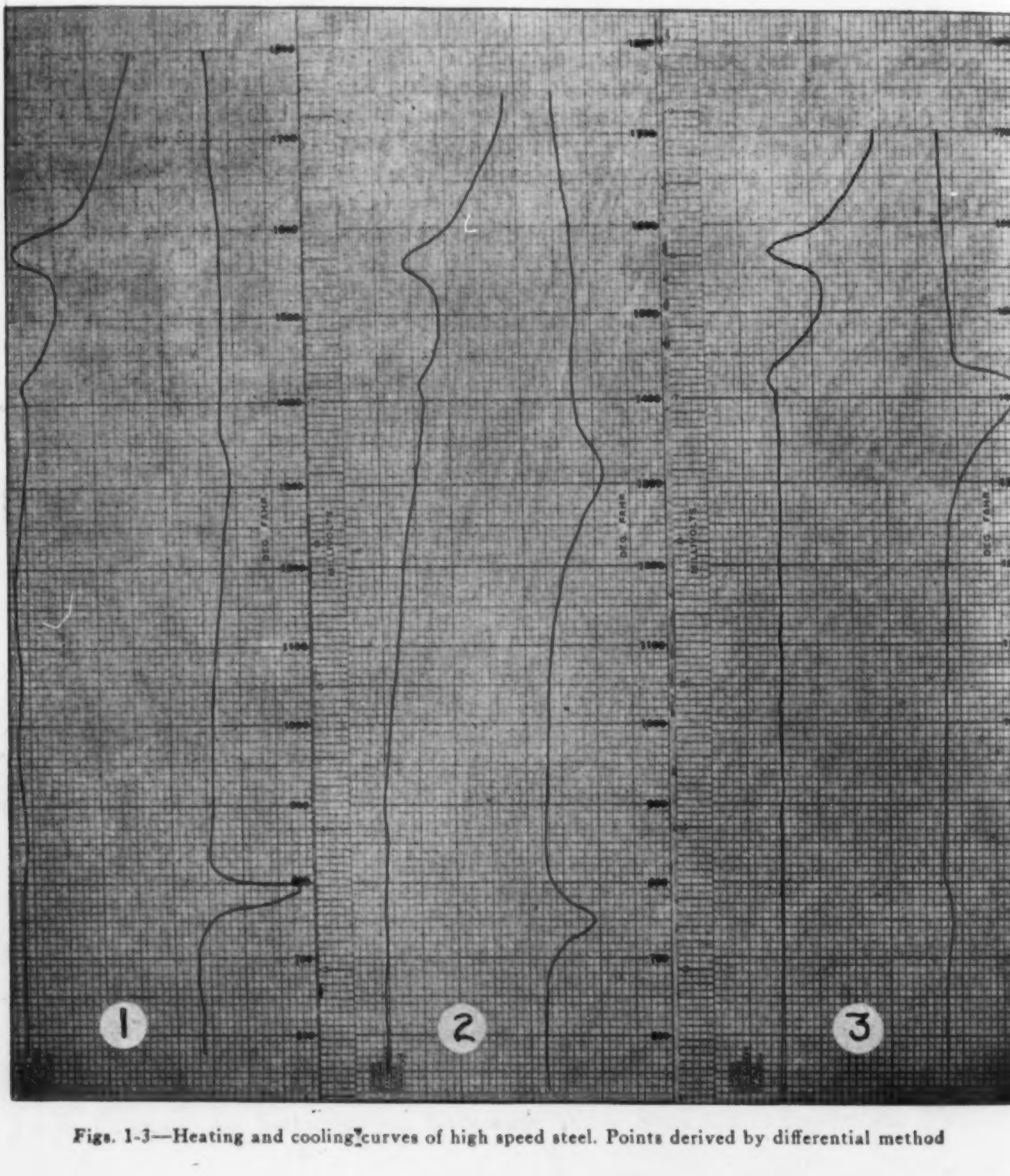
and this tungstide seems to prevent the recombination of chromium and Cr_3C_2 thus causing the lowering of the transformation."

Reference will be made to this theory later; however, it is interesting to note here that the results given have been deduced nearly altogether from magnetic analysis.

Edwards and Kikkawa[2] briefly discussed the constitution of high speed steels in a paper before the Iron and Steel Institute in 1915, but they made no attempts to give exact chemical composition of the constituents. Professor Arnold[3] studied the constituents of high speed steels by analyses of residues and his paper presented also before the Iron and Steel Institute in 1919 is highly interesting.

Other papers by Honda and Murakami[4] and by Hultgren[5] on tung-

2. Journal Iron and Steel Institute, 1915, page 6
3. Journal Iron and Steel Institute, 1919.
4. Revue de Metallurgie, January, 1920. p. 37.
5. Metallographic Study of Tungsten Steels. J. Wiley & Sons, 1920.



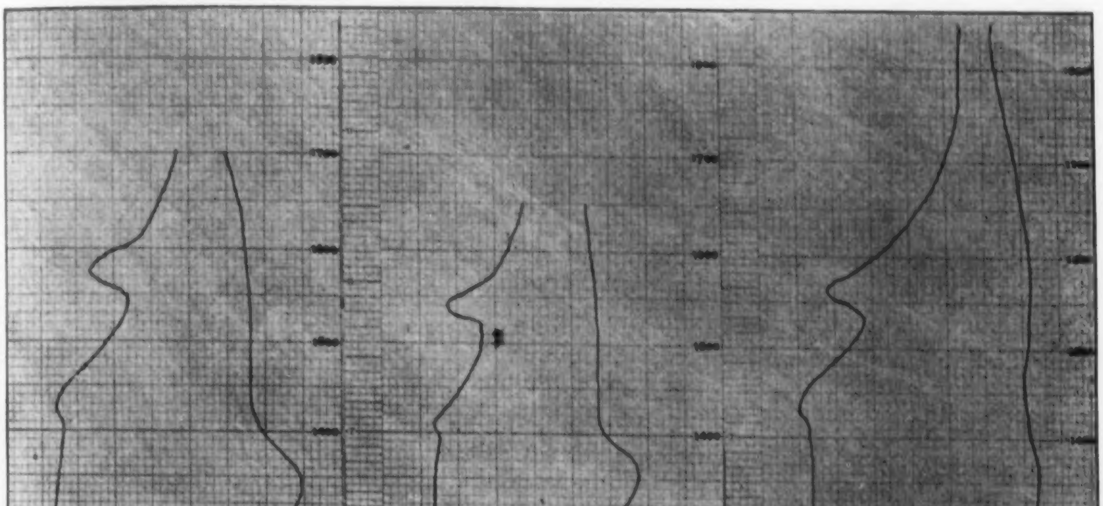
Figs. 1-3—Heating and cooling curves of high speed steel. Points derived by differential method

sten steels lend an interesting aspect to the constitution of high speed steel. Papers by Carpenter[6], Yatsevich[7], and Andrew and Green[8] fully discuss the critical points in high speed steel, while a large number of other investigators have likewise contributed to the knowledge of this phase of high speed steels.

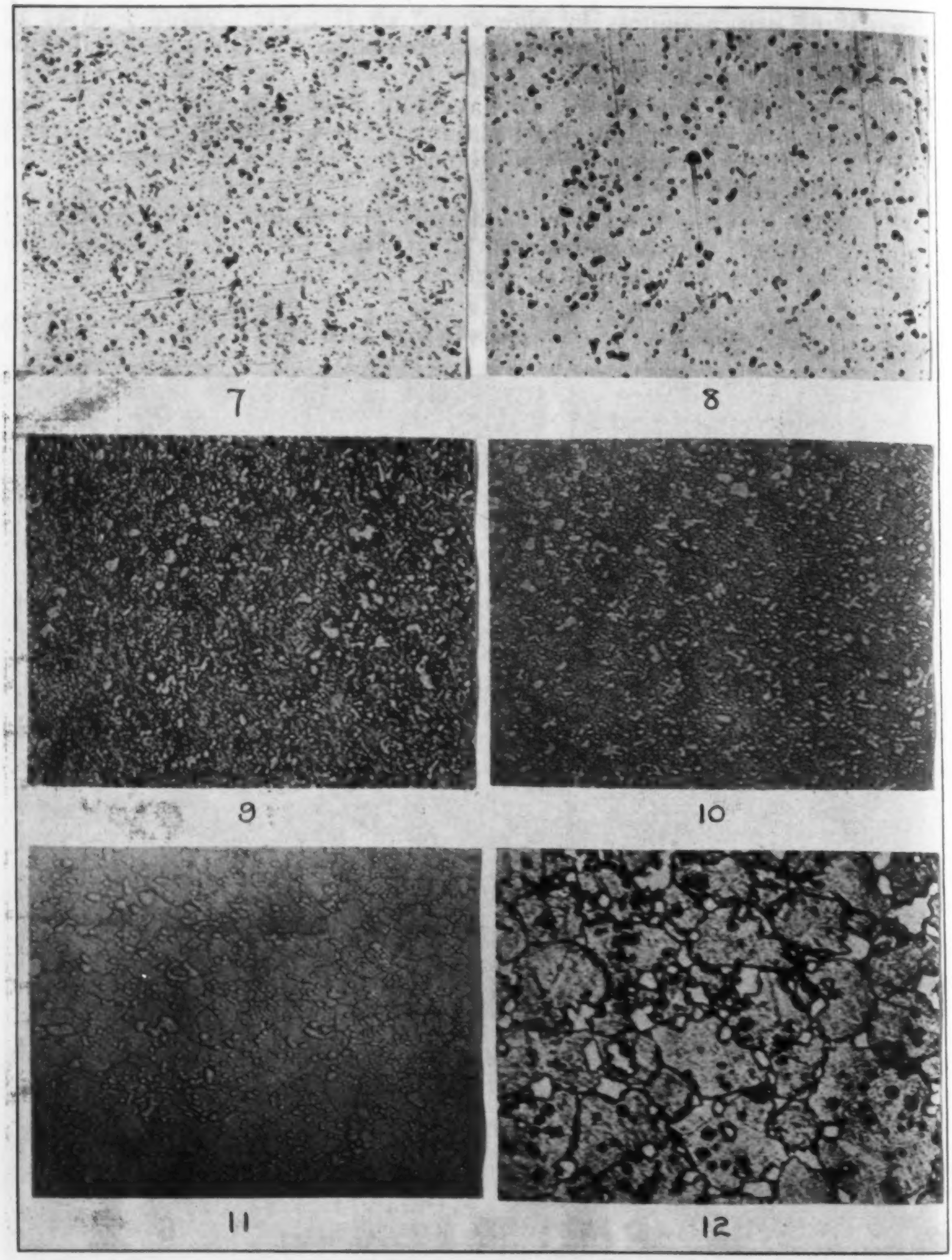
In presenting this paper we have found it necessary to group our experiments under a number of headings. These headings will be taken up not in the order of their importance, but in such an order that we believe will prove the clearest.

Critical Points—A number of heating and cooling curves have been made, a few of which are reproduced in Figs. 1-6. These points were derived by using the differential method. The rate of heating and cool-

6. Journal Iron and Steel Institute, 1902. p. 433; 1906, p. 377.
7. Revue de Metallurgie, 1918. p. 65.
8. Journal Iron and Steel Institute, 1919. p. 305.



Figs. 4-6—Heating and cooling curves of high speed steel. Points derived by differential method



Figs. 7-8—High speed steel showing tungstides going into solution. Fig. 7 was quenched at 2100 degrees Fahr. and Fig. 8 at 2380 degrees Fahr. Etched in sodium hydroxide—hydrogen peroxide and X250 Figs. 9-10—Micrographs showing advantage of picric acid over nitric acid as etching reagent. Fig. 9—Etched with picric acid; Fig. 10, with nitric acid. Both X500. Figs. 11-12—Hardened high speed steel specimens etched with alcoholic solution of nitric acid. Both X500

ing was practically the same for all the specimens. The steel used in obtaining the curves was in the annealed state and had an analysis as follows:

	Per cent
Carbon	0.69
Silicon	0.23
Manganese	0.29
Sulphur	0.008
Phosphorus	0.018
Tungsten	18.55
Chromium	3.82
Vanadium	1.01

It will be noticed in all the heating curves that there are distinct decalescence points beginning at a temperature of about 1400 and 1530 degrees Fahr. and reaching a maximum respectively at the temperatures of 1420 and 1570 degrees Fahr. The upper of the two points begins considerably more intensely than the lower, and is also more prolonged. These points are extremely constant, and Sauveur[9] has suggested that since the two points occur within such narrow limits it is possible that they do not indicate two distinct transformations but represent two phases or stages of the same transformation. This view seems untenable since if the two points represented two phases of the same transformation, a change in the heating rate would alter the constancy of the positions in which they occur; also if the heating was stopped between the two points the transformation already begun would be likely to go to completion by holding the temperature; this however is not the case. In Fig. 3 heating was stopped at 1700 degrees Fahr. and the temperature was allowed to fall immediately, the rate of cooling being marked on the diagram. A distinct recalescence takes place beginning at 1420 degrees Fahr. and reaching a maximum at 1370 degrees Fahr. while at 790 degrees Fahr. another feeble decalescence point may be discerned that likely would remain unnoticed if it were not for the other diagrams that develop this point so clearly. In Fig. 2 heating was stopped at 1750 degrees Fahr. and cooling allowed to commence at once. The two recalescence points seem to be of about the same intensity at their maximum but the higher point is much more prolonged.

In Fig. 1 where the heating was stopped at 1800 degrees Fahr., the upper point is barely noticeable while the lower point is intense. In Fig. 6, heating was stopped at 1850 degrees Fahr. and the curve thus developed is practically the same as in Fig. 1, where the heating was stopped at 1800 degrees Fahr. In Fig. 5 the heating was stopped at 1650 degrees Fahr. but the specimen was held at this temperature for 30 minutes before cooling started. Two distinct points are noticeable, while in Fig. 3 the lower point can barely be noticed yet the specimen was heated to a temperature 50 degrees higher. In Fig. 4 the temperature was likewise held for 30 minutes this time at a temperature of 1700 degrees Fahr. and the two recalescence points have about the same maximum intensity. This curve corresponds closely to Fig. 2 where the maximum temperature reached was 1750 degrees Fahr. The rate of heating and cooling the specimen was practically the same in producing each curve.

It will be noticed that the two recalescence points remain fairly constant and as one is suppressed the other is intensified, indicating two

The Metallography and Heat Treatment of Iron and Steel, Sauveur & Bolyston, 1918.

distinct points, and not the shifting of one point to another position. The transformation taking place therefore at the upper decalescence point apparently does not go to completion upon reaching the temperature at which the point is indicated on the diagram but depends upon the temperature reached above this point and the time held at this temperature. This is further substantiated by the prolonging of the point after the maximum has been passed.

The first decalescence point thus seems to result from the carbon contained in the sorbite going into solution or the formation of austenite, while the upper decalescence point results from the commencing of the solution of the tungstides which depends upon time and temperature for completeness, in proof of which are shown two micrographs, Figs. 7 and 8, of the same piece of high speed steel, Fig. 7 of which was quenched from 2100 degrees Fahr., and the other from 2380 degrees Fahr. A comparison shows how much more completely the tungstides have gone into solution in the specimen quenched from the higher temperature.

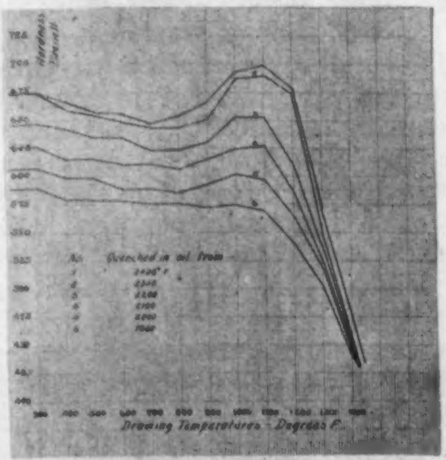
The recalescence points do not permit of as easy an explanation. It is feasible, however, that the upper point represents the transformation of the austenite, and the lower point the forming of the tungstides from solution. This is the reverse of what is expected in most steels where the last transformation to take place on heating is the first transformation to take place on cooling. Yet, as shown by the curves, as the upper recalescence point is suppressed, the lower point is intensified, and as the lower point is intensified more tungstides have been dissolved either by heating to a higher temperature or by holding at a temperature above the upper decalescence point. It would then seem that as the tungstides went into solution the transformation of the austenite would be retarded and the upper recalescence point would occur at a lower temperature, but here it is actually suppressed more and more by the solution of the tungstides until no point exists. As the solution of tungstides becomes greater the lower decalescence point increases in intensity indicating a direct relationship, or that the lower point is where the tungstides form from solution.

Secondary Hardness—Bearing more or less direct relation to the critical points of high speed steel is what is termed "the phenomenon of secondary hardness" which we do not consider a phenomenon at all, but a natural occurrence. Howard Scott[10] classified a number of quenched specimens into two groups, one of which exhibits secondary hardness and which were quenched from a temperature above 2000 degrees Fahr. and the other which did not exhibit secondary hardness and which were quenched from a temperature less than 2000 degrees Fahr. Fig. 13 shows a chart which bears out his classification very well.

A microexamination of a number of specimens shows that the secondary hardness increases in a direct proportion to austenization. So it is well that consideration be given here to the effect of the different elements on secondary hardness or in truth on austenization.

A carbon steel containing 1.10 per cent carbon may be hardened by quenching in water from 50 degrees above its critical point to obtain a Brinell hardness of nearly 700, yet it does not show a secondary hardness on tempering, and its structure is plainly martensitic. A steel containing 0.97 per cent carbon and 4.05 per cent chromium with no

10. Scientific Paper No. 395, Bureau of Standards.



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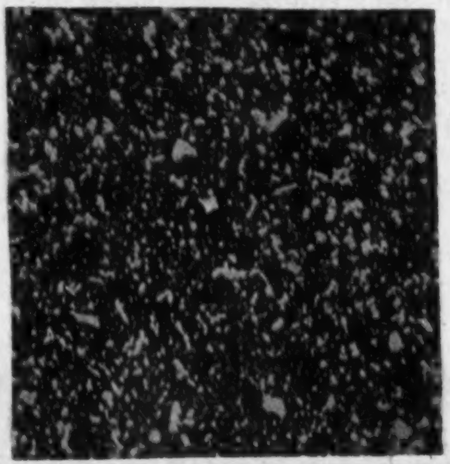

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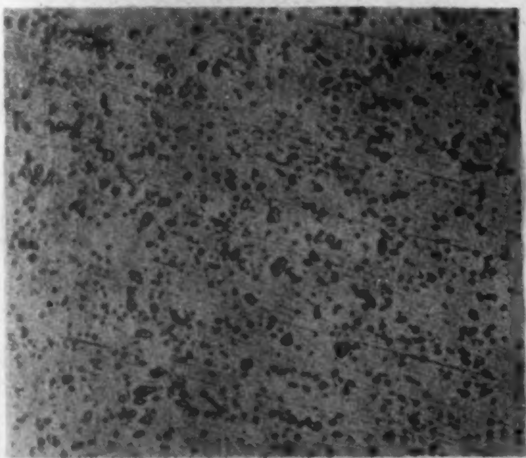

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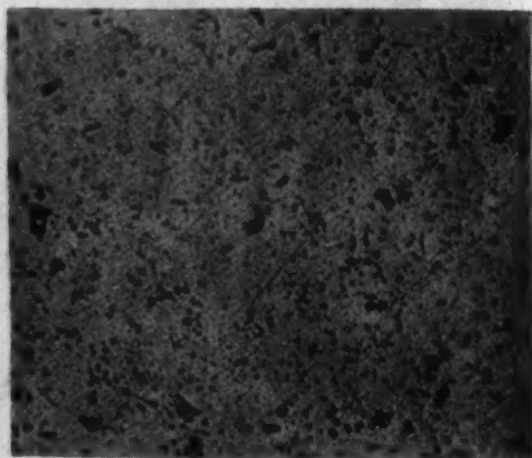

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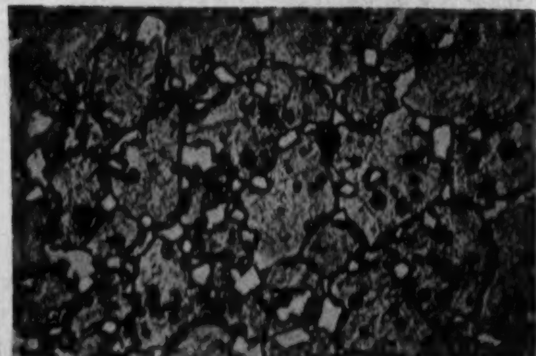

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Fig. 13—Chart showing classifications as to secondary hardness. Fig. 14—Heat tinted specimen showing development of structure although not as clearly defined as when picric acid is used. X500. Fig. 15—A specimen etched with sodium hydroxide—hydrogen peroxide. X500. Fig. 16—A specimen etched with potassium hydroxide and $K_3 Fe (CN)_6$ X500. Figs. 17-18—Micrographs of hardened high speed steel showing polyhedral structure Etched in nitric acid and X500

tungsten can be hardened in air from 1650 degrees Fahr. and will exhibit extreme hardness if quenched in oil but such a steel does not show a perceptible secondary hardness and a microexamination of the hardened steel shows a martensitic structure. Moreover, in making cooling curves of a steel with a variable chromium content, the maximum temperature from which cooling begins, does not have an appreciable influence on the position of the recalescence points.

A steel containing 0.68 per cent carbon and 15 per cent tungsten when quenched in oil from 2000 degrees Cent. shows only a hardness of about 500 Brinell but does exhibit a slight secondary hardness. How-

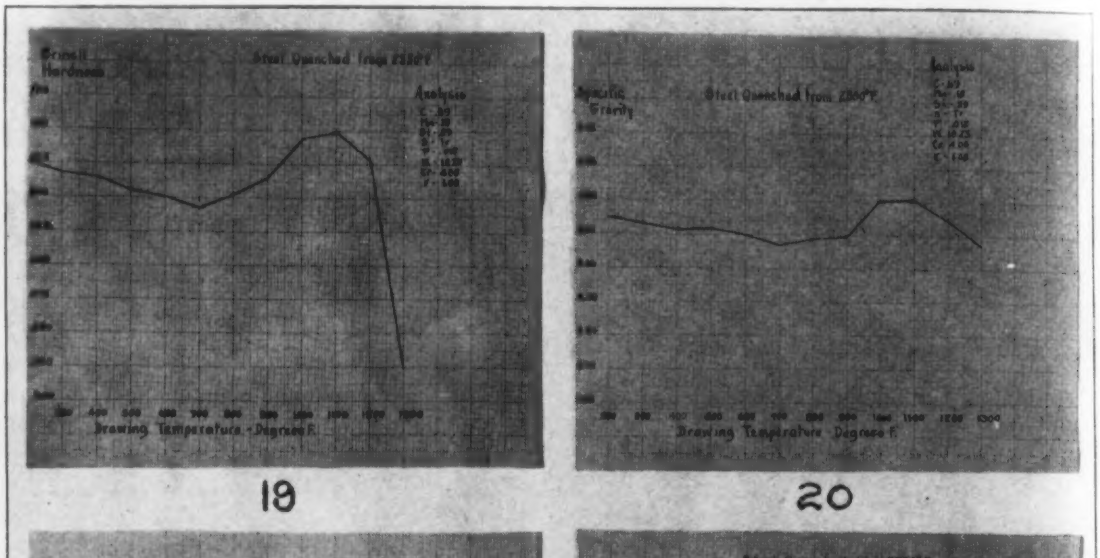


Fig. 19—Curve showing hardness of austenite as compared with martensite. Fig. 20—Curve showing specific gravity of austenite as compared with martensite. Fig. 21—Curve showing changes in maximum magnetic induction by drawing hardened high speed steel. Fig. 22—Curve showing changes in residual magnetic induction by drawing hardened high speed steel

ever in such a steel most of the tungstides remain undissolved regardless of the temperature from which quenching takes place. The temperature from which cooling curves are made on such a steel does influence the position of the recalescence points. Thus it is a combination of the three elements—carbon, chromium and tungsten—not one nor a combination of two, that depress the critical range to such a degree that an austenitic steel can be produced by practical heat treating methods, which being tempered to the harder constituent martensite produces secondary hardness. It is a natural result, and seems unusual only since austenite is not produced in most steels by commercial heat treatment.

Etching Reagents—A number of etching reagents have been used for the development of the microstructure of high speed steels with various results. An alcoholic solution containing from 1 to 4 per cent nitric acid has been used on annealed or hardened and highly drawn specimens. A 4 per cent solution reacting on annealed specimens requires only some 30 to 40 seconds to fully develop the structure, while the same solution reacting on a hardened and highly drawn specimen requires from 1½ to 3 minutes to develop the structure. We have not found, however, nitric acid as valuable an etching reagent for annealed specimens as an alcoholic solution diluted with from 10 to 15 per cent water and saturated with picric acid. This solution develops the matrix in greater detail than does nitric acid as shown by Figs. 9 and 10.

Neither of the two reagents color the tungstides and they remain clearly revealed as white embedded globules. On specimens hardened and not drawn an alcoholic solution containing from 6 to 8 per cent nitric acid reacting on the specimen from 3 to 6 minutes will clearly develop the polygonal structure that is characteristic of hardened high speed steel, while on specimens of this type picric acid reacts exceedingly slow, and even after an immersion of an hour the structure is but faintly developed. Figs. 11 and 12 are of hardened specimens etched with an alcoholic solution of nitric acid.

An alcoholic solution containing from 2 to 5 per cent nitric acid and saturated with picric acid does not develop the structure of annealed specimens as well as the picric acid alone, and seems to offer no advantage in the etching of the hardened specimens over a nitric acid solution. It is readily apparent when using these etching reagents that the time required for the development of the structure is a direct indication of the heat treatment the steel has received, and many times valuable information can be obtained concerning the treatment of the steel by timing the etching.

Heat tinting will develop the structure of annealed specimens as the result of a thin coat of iron oxide forming over the matrix while the embedded tungstides remain unchanged. This is shown by Fig. 14. We have not found any advantage in using this method for the development of the microstructure, as the matrix is not as clearly defined as when using picric acid.

A solution made up of 30 per cent commercial hydrogen peroxide and 10 per cent sodium hydroxide and the remainder water, proved valuable for etching the tungstides a dark brown and black while leaving the matrix apparently unetched. This solution works equally well on all specimens, regardless of the condition in which they exist. It is necessary however, to make up the solution shortly before using as it

disintegrates rapidly and loses its strength. A specimen etched with this solution is shown by Fig. 15. The etching time is from 10 to 15 minutes and as only the tungstides are etched the time remains the same on all specimens regardless of their heat treatment.

Another solution from which etching results can be obtained quite similar to the solution just mentioned is made up of 10 grams potassium or sodium hydroxide and 10 grams $K_3Fe(CN)_6$ in 100 cubic centimeters of water. Practically the same results were obtained by using this solution as the sodium hydroxide-hydrogen peroxide solution. This solution will etch the tungstides much more rapidly, as the etching time is only from 30 to 50 seconds. Another advantage this solution has over the sodium peroxide solution is its stableness, as it may be preserved for three or four months without apparent decomposition. A specimen etched with this solution is shown in Fig. 16.

Nomenclature—The question of nomenclature of the constituents of high speed steel other than the tungstides or carbides often arises, and you have probably asked yourself whether or not the nomenclature of the constituents of a carbon steel are applicable to a steel that is really approaching an alloy for 25 per cent of the composition of high speed is not iron. From evidence that follows and considering the broadness of the definitions of the nomenclature of the constituents of carbon steel, we believe that the same nomenclature is applicable to the constituents of high speed steel.

Austenite as it is defined is the solid solution of iron and carbon as it exists above the transformation range or as preserved at lower temperatures by rapid cooling or by the presence of retarding elements. It may contain carbon up to the saturation point, namely 1.7 per cent carbon. It is polyhedral and is darkened less by the acid etching reagents than troostite, sorbite and martensite. Its hardness is variable depending on the state in which it is preserved, but is usually never considered as hard as martensite. It is slightly magnetic and does not show as great a volume change in passing from pearlite or sorbite into austenite, as does martensite. Considering the austenite of high speed steel, it is primarily a solid solution of iron and carbon plus dissolved tungsten, chromium and vanadium. That it is polyhedral is evidenced by any micrograph of hardened high speed and is shown here by Figs. 17 and 18.

That it is darkened less by the acid reagents than are martensite, troostite and sorbite is shown by the etching time necessary for etching steels containing these constituents and previously mentioned. Its hardness is not as great as that of martensite as shown by the diagram in Fig. 19. That it occupies a smaller volume than does martensite is evidenced by this diagram in Fig. 20 of the change in specific gravity by drawing hardened high speed steel. The austenite of high speed steel is also feebly magnetic, and in Figs. 21 and 22 are two diagrams showing the changes produced in hardened high speed steel in maximum and residual magnetic induction by drawing.

Next, considering martensite which is defined as the first stage in the transformation of austenite characterized by needle-like structure and great hardness. Its hardness exceeds that of any other constituent produced in the transformation of austenite with pearlite. It is magnetic. It etches darker with acid reagents than austenite but lighter than troostite. It represents a metastable condition in which the steel is

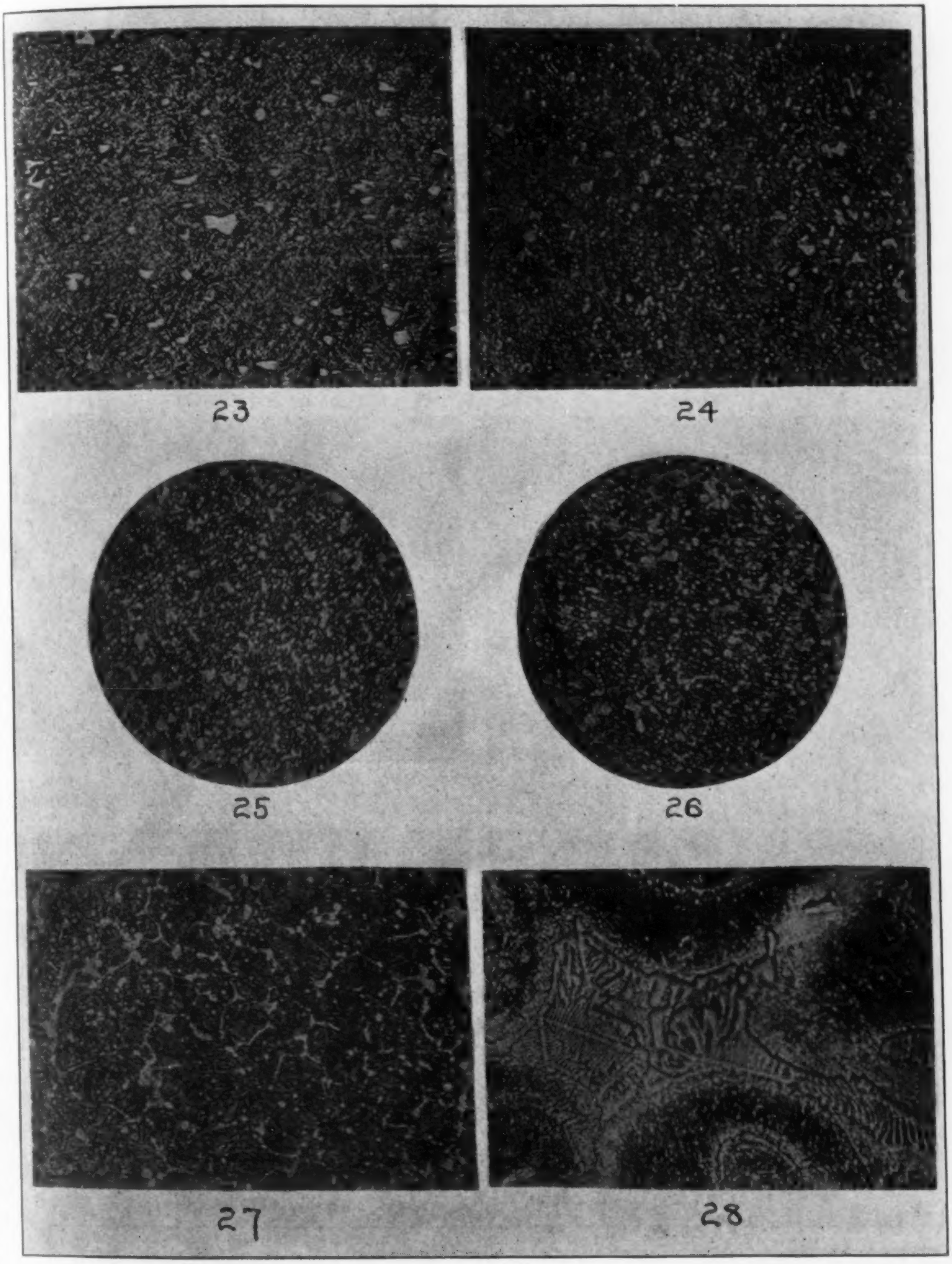


Fig. 23—Martensite as developed in high speed steel. Etched with nitric acid and X500. Fig. 24—Sorbite as developed in high speed steel. Etched with picric acid and X500. Fig. 25—Annealed high speed steel of 228 Brinell hardness. Fig. 26—Hardened high speed steel drawn to 1450 degrees Fahr. and of 444 Brinell hardness. Both Figs. 25 and 26 were etched with picric acid and X500 and show difficulty in distinguishing troostite. Fig. 27—Micrograph showing coalescence of imbedded globules. Etched with nitric acid and X500. Fig. 28—Globules in an ingot representing a single eutectic mixture. Etched with nitric acid and X1100

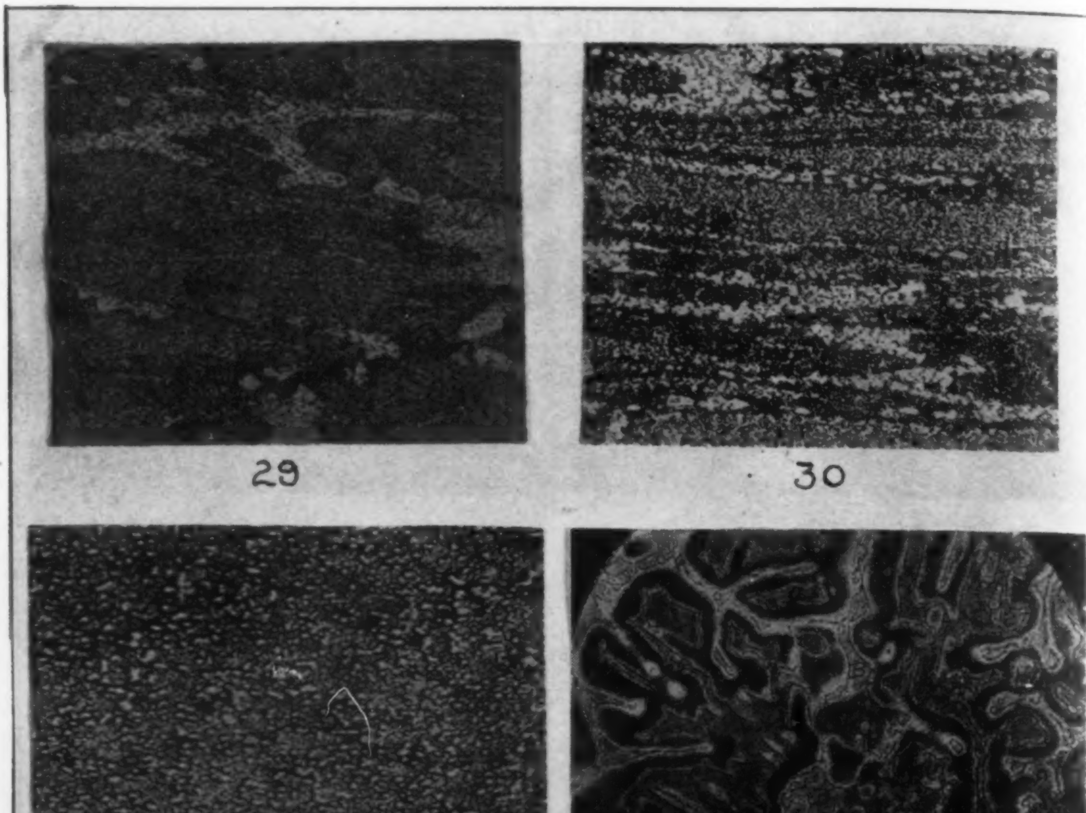


Fig. 29—As working of ingot begins eutectic mixture of globules breaks up. Etched with nitric acid and X275. Fig. 30—Elongation of globules into stringers caused by further working of ingot in same direction. Etched with nitric acid and X275. Fig. 31—Characteristic distribution of globules after upsetting or further reduction of ingot. Etched with nitric acid and X500. Fig. 32—Structure of high speed steel ingot as cast. Etched with nitric acid and X200. Fig. 23—Upon annealing the ingot only two constituents are noticeable. Etched with nitric acid and X500. Fig. 34—Structure represented by etching specimen in Fig. 33 with sodium hydroxide—hydrogen peroxide. X1100

caught during retarded transformation as austenite is passing into a mixture of ferrite and cementite.

Comparing the martensite as developed in high speed steel, Fig. 23, it is certainly the first stage in the transformation of austenite, as characterized by its increasing hardness, greater volume, and considerably higher values for residual and maximum magnetic induction. It is likewise distinguished by its needle-like structure and high speed steel existing in the martensitic state is in its hardest state. It etches darker than austenite but does not etch as rapidly as troostite or sorbite. That it represents a metastable condition is evident, since by quenching high speed steel from a high temperature austenite is produced which can be readily changed into martensite by heating to 1100 degrees Fahr., while heating to a higher temperature destroys the martensite.

Considering next in order, troostite, it is defined as the stage in the transformation of austenite that follows martensite and precedes sorbite. That it is an uncoagulated conglomerate, and that the degree of completeness of the transformation it represents is not definitely known and probably varies widely. It is not always easily and definitely discernible under the microscope, as it occurs in an irregular manner. Acid etching reagents darken it more than martensite or sorbite, one or both of which usually accompany it. Its hardness is intermediate and its magnetic properties are indefinite.

Troostite as it should exist in high speed steel is the most indefinite of the constituents in the transformation of austenite. Under the microscope it is exceedingly difficult to distinguish and two micrographs, Figs. 25 and 26, bear evidence of this fact. Fig. 25 is of annealed high speed steel having a Brinell hardness of 228, while Fig. 26 is of hardened high speed steel drawn to 1450 degrees Fahr. and has a Brinell hardness of 444. There is practically no difference in the appearance of the matrix. This micrograph of the specimen drawn to 1450 degrees Fahr. was chosen as representative of the microstructure that apparently exists after the disappearance of the martensite. This structure can hardly be called sorbite, as sorbite in high speed steel represents a stable condition, while the physical and magnetic properties co-existing with this structure vary to a great degree as a result of heat treatment. Its properties are intermediate as are the properties of troostite in carbon steel. Acid etching reagents, however, apparently darken it to about the same degree as sorbite in high speed steel. That it represents a step in the transformation of austenite is apparent from its physical and magnetic properties which are intermediate. Thus even though microscopically troostite cannot be satisfactorily distinguished, in view of the broadness of the definition of the term, there is justification of giving the name troostite to that structure that exists between martensite and stable sorbite.

Sorbite as defined is the stage in the transformation of austenite following troostite and preceding pearlite. It is usually considered as an uncoagulated conglomerate of pearlite with ferrite or cementite depending on the carbon content of the steel, but that it may contain some incompletely transformed matter. It is not resolvable under the microscope and cannot properly be represented on the equilibrium diagram, hence it represents a metastable condition. Considering the sorbite of high speed steel as shown by micrograph, Fig. 24, it follows troostite as we have so considered it in the transformation of austenite. It is not resolvable under the microscope. It represents a stable condition and in this respect resembles the pearlite of carbon steel, and would

therefore be represented on the equilibrium diagram below Ac_1. This is evidenced by the fact that a resolvable constituent of high speed steel similar microscopically to the pearlite of carbon steel is not to be obtained. Regardless of the treatment that may be given to high speed steel, sorbite apparently represents the end in the transformation of the austenite, thus becoming a stable constituent and deserving of representation on the constitutional diagram where the pearlite is represented in carbon steels. The pearlite of carbon steels partly corresponds to the sorbite of high speed steel as just mentioned, and not bearing a true resemblance to any constituent in high speed steel will not be described.

Imbedded Globules—The chemical composition of the matrix and of the embedded globules of high speed steel in its different states presents an interesting study that few investigators have attempted. Honda's[1] theory that in the annealed condition high speed steel was composed of iron-dissolving tungstide, free tungstide, chromium carbide and tungsten carbide is difficult of conception in view of some of the following evidence.

Every manner of etching the specimen that has been tried results in all the globules having exactly the same appearance, while if the globules were of different composition it seems that some of the various manners of etching would have attacked them differently. Second, from preliminary observations the melting points of Fe_2W, Cr_4C and WC vary widely; we may then assume that their rate of absorption or solution by the iron-dissolving tungstide would vary likewise; yet neither thermal nor magnetic curves reveal critical points that indicate a differential solution of the globules. Third, when high speed steel is heated to a temperature approaching its melting point there is a distinct coalescence of the embedded particles which structure becomes normal and can only be obliterated by quenching from exceeding high temperatures. This structure is shown by Fig. 27. This mixture of the globules behaves in exactly the same manner as before they coalesced; that is, it etches similarly and does not affect the critical points; thus if before coalescing the globules had been of different compositions we would expect that after mixing they would either etch differently or affect the critical points. Fourth, in tracing the history of the formation of the globules from the ingot we find that in the ingot they represent a single eutectic mixture which will be considered later and is here shown by Fig. 28. This formation by working begins to break up as shown in Fig. 29, and by further working in the same direction will become elongated into stringers as shown by Fig. 30, and finally by upsetting or by further reduction take the characteristic distribution as shown here by Fig. 31. If then the globules were of different composition there seems to be no place in the history of the steel that allows for their formation.

Professor J. O. Arnold[11] isolated and analyzed a number of tungstide residues from high speed steel of varying analyses. His results are quite interesting and here is given one analysis of a high speed steel he used and the analysis of the residue obtained:

	Per cent
Carbon	0.55
Chromium	2.62
Tungsten	15.92
Vanadium	1.16
Silicon	0.34
Sulphur	0.058
Phosphorus	0.017
Manganese	0.20

1. Journal Iron and Steel Institute, 1919.

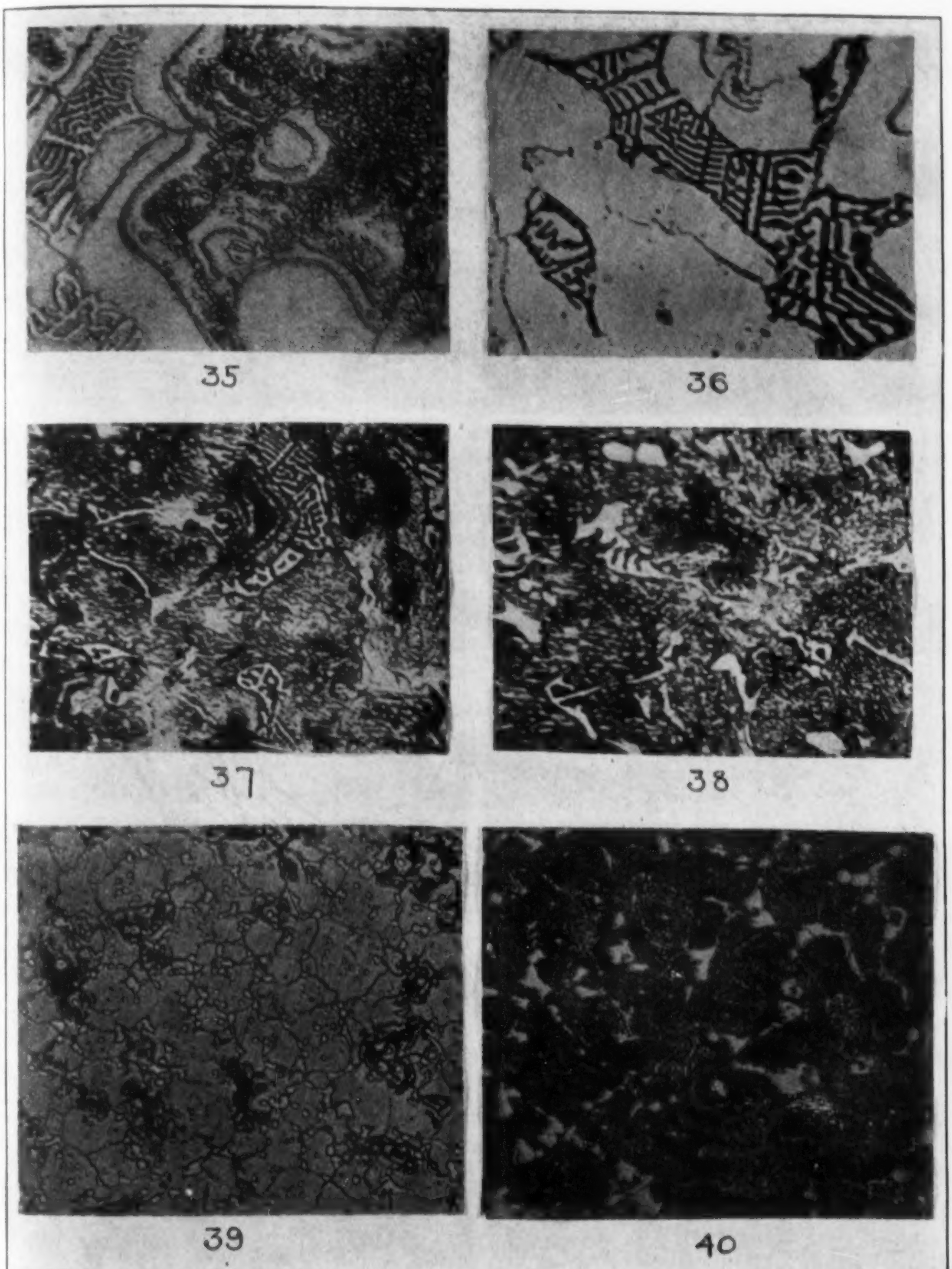
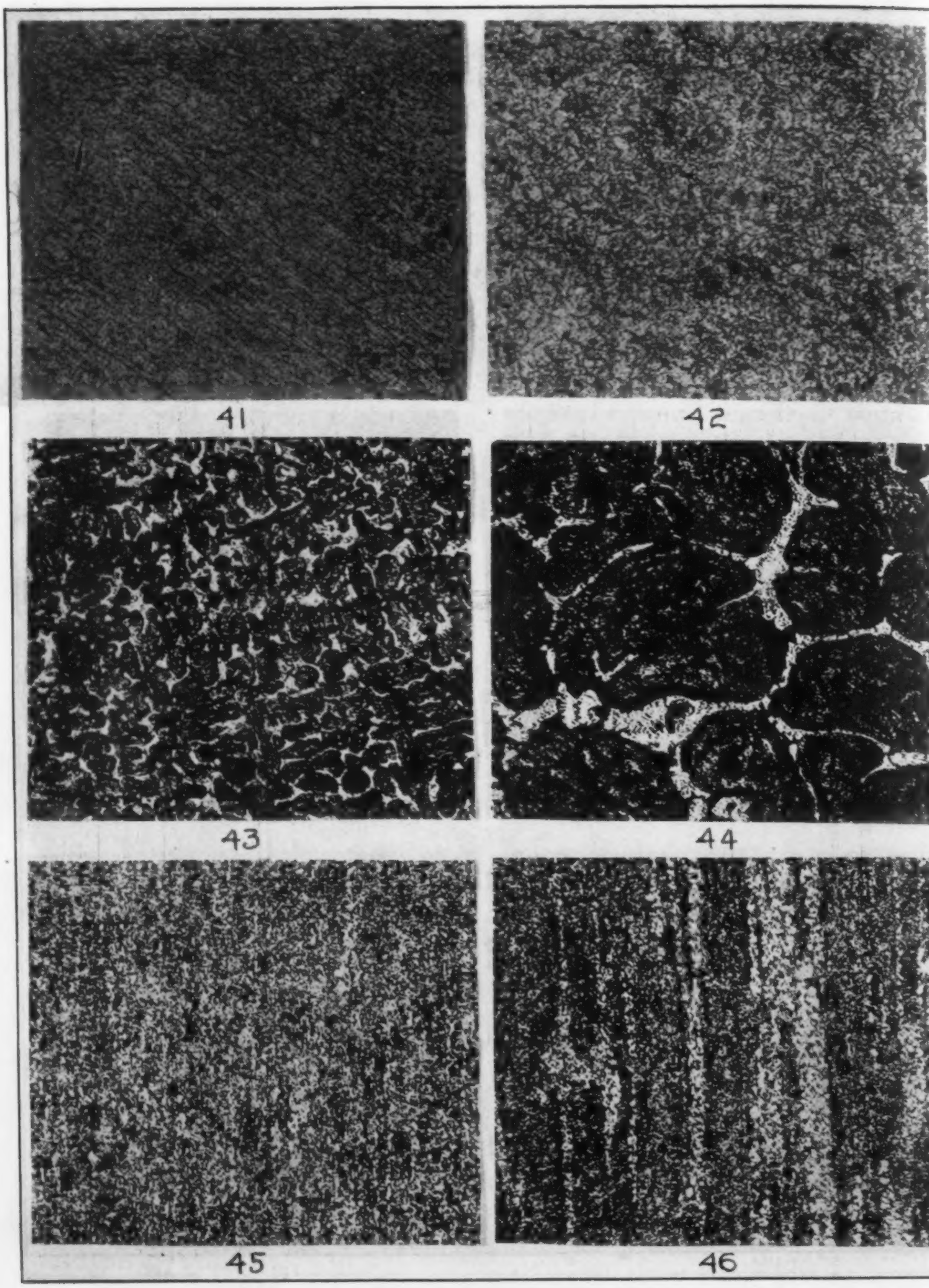


Fig. 35—Structure developed in high speed steel by hardening from temperature at which actual fusion of the tungstide takes place. Etched with nitric acid and X1100. Note similarity to ingot as cast, Fig. 32. Fig. 36—Structure of specimen, Fig. 35, after etching with sodium hydroxide—hydrogen peroxide. X1100. Figs. 37-38—Micrographs taken along a bar, one end of which was held at room temperature while the other was melted. Etched with nitric acid and X500. Fig. 39—Black areas representing an actual fusion of the tungstide. Etched with nitric acid and X500. Fig. 40—Annealed specimen, the small faint areas of the tungstide being the same as the black areas in Fig. 39. Etched with nitric acid and X500



Figs. 41-42—Micrographs in which no carbides of chromium can be distinguished and which have appearance of a perfect solution of the chromium. Etched with nitric acid and X500. Figs. 43-44—Micrographs showing distribution of tungstides. Fig. 43 taken 1/8 inch from outside of ingot and Fig. 44 taken 2½ inches from outside of same ingot. Etched with nitric acid and X500. Fig. 45—Micrograph of specimen rolled from 1½ inch square cut from outside of 7-inch ingot. Etched with nitric acid and X500. Fig. 46—Micrograph of specimen rolled from 1½-inch square cut from center of same ingot. Etched with nitric acid and X500

Weight steel dissolved Grams	Weight of residue obtained Grams	Carbon Per cent	Iron Per cent	Chromium Per cent	Tungsten Per cent	Vanadium Per cent
8.7718	2.0144	2.33	23.96	3.13	64.24	4.68
8.9466	2.0426	2.32	23.62	3.13	64.24	4.81

It will be noticed from the above analysis that a proportionally greater percentage of the tungsten is contained in the residue obtained. Thus it would be expected that an increase in the tungsten content would increase the quantity of the globules and this has been confirmed by an examination of a number of high speed steels containing tungsten in varying percentages. Also we have found as did Honda and Murakami[1] that an increase in the percentage of carbon or chromium with the tungsten content remaining the same did not noticeably increase the quantity of the globules. We have also etched a number of specimens of ferro-tungsten containing less than 0.20 per cent carbon and from 65 to 80 per cent tungsten and found that the sodium-peroxide and ferricyanide reagents reacted on it much in the same manner as upon the globules of high speed steel. Thus in view of the evidence presented we believe we are justified in stating that the embedded globules in high speed steel are of a complex but similar chemical composition and should be designated as tungstides instead of carbides though they are not pure tungstides.

Tungstides Are of a Eutectic Composition—The structure of the ingot lends an interesting aspect to the constitution of high speed steel. Fig. 32 shows a micrograph of the ingot as cast taken at 200 diameters magnification. The part of the ingot indicated by *A* probably solidified, first giving rise to a eutectic mixture represented by *B*. But at the same time this eutectic is solidifying areas of the molten solution entrapped by the first solidification precipitates the same eutectic, *C*, since the solution by partly solidifying enriches the remainder in those elements that will produce the lowest melting mixture.

Upon annealing the ingot only two constituents are noticeable as shown by Fig. 33. Then by etching the specimen with H_2O_2 NaOH we get a structure represented by Fig. 34. The eutectic marked *B* corresponds to that marked *B* in Fig. 32 and the eutectic marked *C* likewise corresponds to that marked *C*. Thus from evidence presented elsewhere in this paper these two constituents are the same, differing only in quantity as one has been precipitated from a mixture richer in the eutectic than the other. Thus the embedded tungstides in high speed steel must represent a eutectic mixture and as the eutectic changes with a change in the composition of the steel, the carbides do not represent a composition of a constant chemical formula.

While studying the structure of the ingot it is interesting to note the structures developed in high speed steel by hardening from a temperature at which an actual fusion of the tungstide takes place. In Fig. 35 the structure is comparable to the structure of the ingot as cast where there exists a large skeleton of the eutectic and an area of the eutectic having a more granular appearance. By etching the specimen from which this micrograph was made with (NaOH) - (H_2O_2) we get a structure as is shown by Fig. 36. That the skeleton of the eutectic of tungstides here represented is a fusion of the tungstides is evidenced by

Figs. 37 and 38 taken along a bar, one end of which was held at room temperature while the other was melted. A coalescing of the tungstides is very pronounced.

The black areas represented in Fig. 39 we believe were one time named "the brittle constituent" by a well-known English metallurgist and have been at other times called troostite, and only recently a similar micrograph was used by a well-known authority to represent correctly hardened high speed steel. These black areas however are the same as those shown in Fig. 35, and represent a fusion. In proof of this and also in proof that the areas are not troostite, the specimen from which this micrograph was made was annealed and Fig. 40 represents the result. Notice that the small faint areas of the tungstide are the same as the black areas in Fig. 39, and compare with the granular areas shown in Fig. 35 showing that a eutectic has resulted from an incipient fusion.

Influence of Chromium on Solution of Tungstides—From analyses of tungstide residues of high speed steel as given by Professor Arnold[11], to one of which reference was previously made, it was noted that the proportionally larger percentage of the chromium existing in high speed steel was to be found in the matrix. This is supported by Figs. 41 and 42 of steel containing 0.30 per cent carbon and 11.93 per cent chromium, and 0.31 per cent carbon and 15.90 per cent chromium, in which no carbides of chromium can be distinguished, and which have the appearance of a perfect solution of the chromium in the iron. Likewise from the analysis of the tungstide residues it is apparent that a proportionally larger percentage of the tungsten is contained in the tungstides, and in a tungsten steel of some 0.70 per cent carbon there exists a large number of embedded globules as would be expected but not near the proportion of these globules will go into solution at high temperatures as the tungstides in high speed steel indicating that iron dissolving chromium has a greater power to dissolve the tungstides than iron alone.

The Distribution of the Tungstides—The distribution of tungstides in high speed steel is of great importance as a poor distribution gives rise usually to a noticeably inferior steel. The following two micrographs, Figs. 43 and 44, are taken from the same ingot, one taken ⅛-inch from the outside and the other 2½ inches from the outside. The magnification of both are the same.

The distribution of the eutectic mixture or of the tungstides is evident as it existed in this ingot. The finer cellular structure is of course the result of the quicker freezing of the outside of the ingot, and as the ingot solidified progressively toward the center, the cellular structure grows coarser in about the same ratio as the rate of solidification of the ingot. Therefore, the correctly cast smaller ingot by solidifying more rapidly than the larger ingot has a more uniform and finer cellular structure. Moreover, obviously the ingot cast at a lower temperature will have a better cellular structure than an ingot cast at a higher temperature. Thus the size of the ingot and the casting temperature by determining the distribution of the eutectic mixture or tungstides determine partly the distribution of the tungstides in the finished product. Figs. 45 and 46 show two micrographs, taken longitudinal of two ¾-inch square bars rolled from different portions of the ingot. Fig. 45 was rolled from a 1½-inch square cut from the outside of a 7-inch ingot, while Fig. 46 was rolled from a 1½-inch square cut from the center of the same ingot.

Both bars received the same kind and amount of work yet the

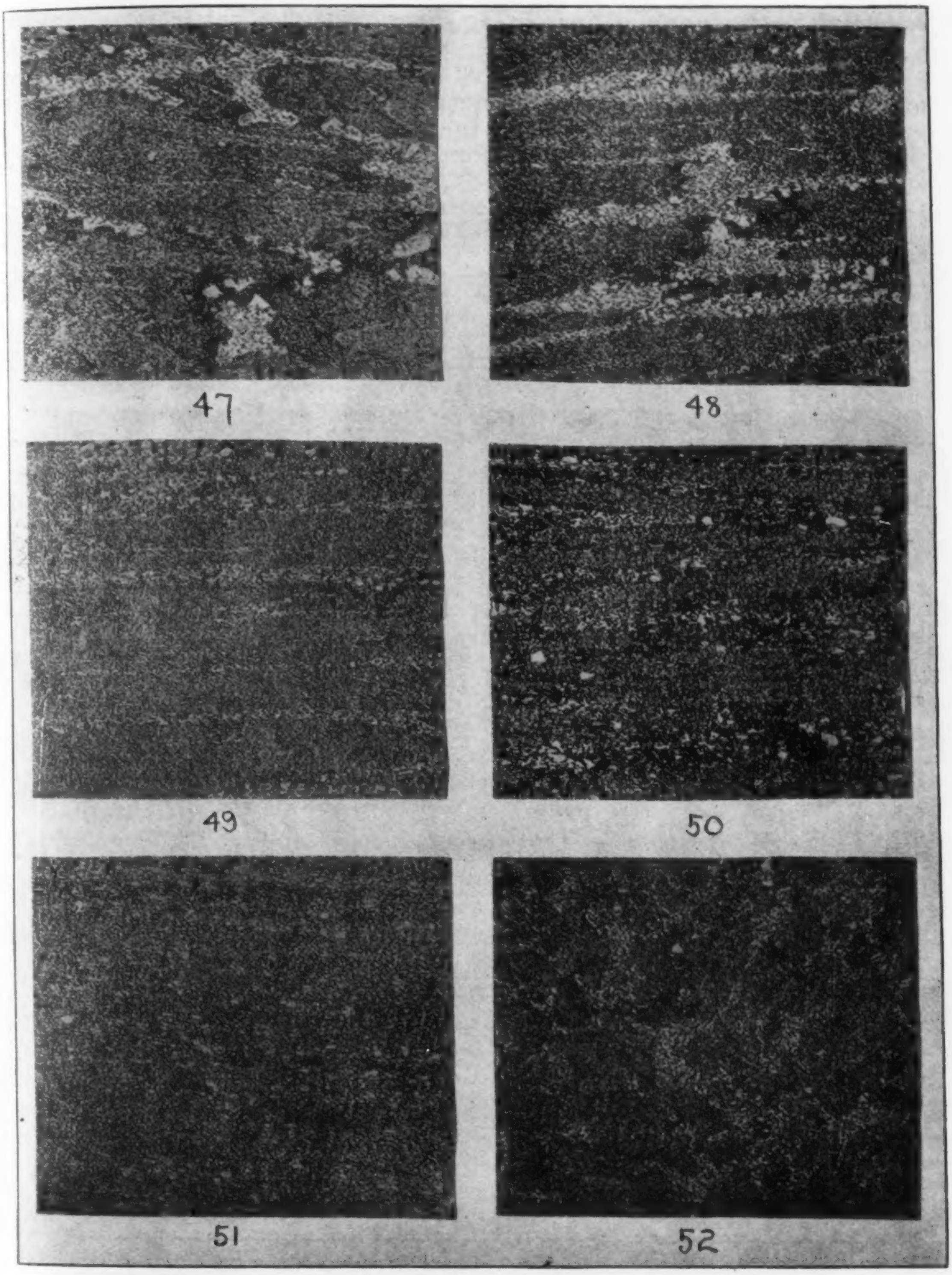
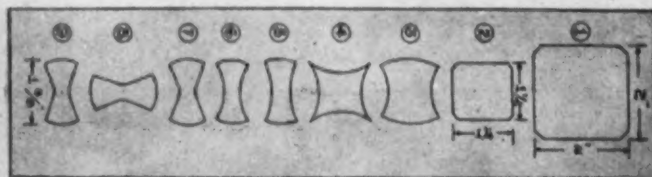


Fig. 47-52—Micrographs of longitudinal sections of ingot after various amounts of work. All etched with nitric acid and X275. Fig. 47—A 5½-inch billet rolled from 7-inch ingot. Fig. 48—A 3½-inch round rolled from 4-inch billet from 7-inch ingot. Fig. 49—A 2¾-inch round from 4-inch billet from 6-inch ingot. Fig. 50—A 1⅛ inch round from 2½-inch billet from 4-inch billet from 6-inch ingot. Fig. 51—A ¾-inch round from 2½-inch billet from 4¼-inch billet from 6-inch ingot. Fig. 52—Distribution of tungstides obtained in a block 9¼ x 6 x 1½ inches by upsetting

tungstide distribution in the bar cut from the outside of the ingot where the cellular structure was finer is far superior to that cut from the inside of the ingot where the cellular was so much coarser. This distribution is further determined by the amount and manner of reduction given the ingot and billet, and a number of micrographs taken of the longitudinal section show clearly the result of the amount of work given an ingot. Fig. 47 is a 5½-inch billet rolled from a 7-inch ingot. Fig. 48 is a 3⅛-



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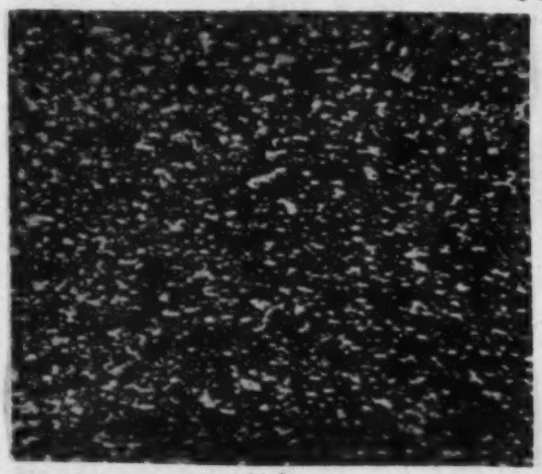

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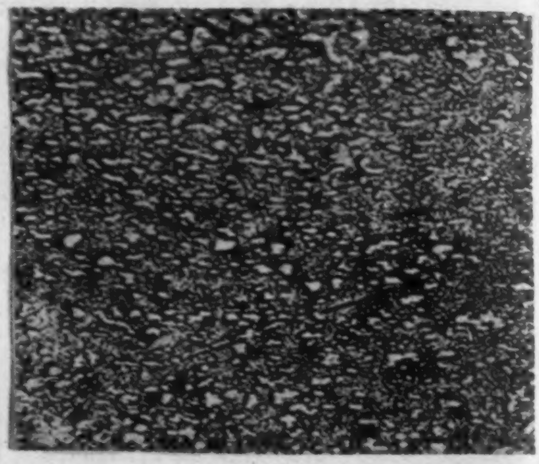

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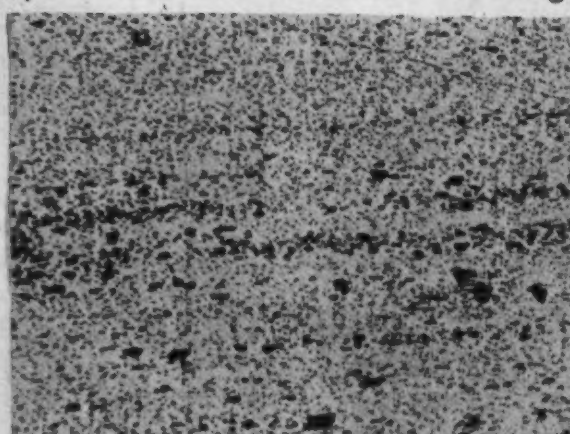

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Fig. 53—Diagram showing how good distribution may be obtained by working steel in same direction but in and out during passes through mill. Figs. 54-55—Longitudinal micrographs of 1⅝-inch drill section rolled according to diagram in Fig. 53. Etched with nitric acid and X500. Fig. 56—Micrograph of 1⅝-inch round rolled in the ordinary manner. Etched with sodium hydroxide—hydrogen peroxide and X275

inch round rolled from a 4-inch billet from a 7-inch ingot. Fig. 49 is a 2¾-inch round from a 4-inch billet from a 6-inch ingot. Fig. 50 is a 1½-inch round from a 2½-inch billet, from a 4-inch billet, from a 6-inch ingot. Fig. 51 is a ¾-inch round from 2½-inch billet, from a 4¼-inch billet from a 6-inch ingot.

In Fig. 51 a perfect distribution has been obtained by working the steel in the same direction, but as this came from a 6-inch ingot the reduction has been very great. If then a good distribution of the tungstides cannot be obtained by ordinary reduction, the manner of reduction must be changed, and Fig. 52 shows a splendid distribution of the tungstides obtained in a block 9¼ x 6 x 1½ inches by upsetting. The micrograph is taken in the direction of the longitudinal section of the bar from which the block was cut and upset.

A good distribution may be obtained by working the steel in the same direction but in and out as illustrated by the diagram shown in Fig. 53 of rolling drill section, where several passes through the rolls are made keeping the bar in a shape similar to that represented by the cross-section No. 4. Figs. 54 and 55 show longitudinal micrographs of a 1⅜-inch drill section rolled according to the diagram.

Fig. 56 shows a micrograph of a 1⅜-inch round rolled in the ordinary manner. From these micrographs the superiority of the manner of rolling the drill section is evident.

Summary—1. The position of the decalescence points in high speed steel are exceedingly constant while the position of the recalescence points depend on the temperature from which cooling begins. The upper decalescence point represents the solution of the tungstides while the lower recalescence point represents their formation. The lower decalescence point and the upper recalescence point represent respectively the transformation of sorbite into austenite, and austenite into a lower constituent.

2. Secondary hardness represents a natural occurrence and is dependent upon the carbon-chromium-tungsten content as well as the temperature from which cooling begins and the rate of cooling.

3. An alcoholic solution saturated with picric acid was found best for the etching of annealed specimens, while an alcoholic solution containing from 6 to 8 per cent HNO_3 was best for hardened specimens. A solution of sodium hydroxide and hydrogen peroxide, and a solution of $K_3Fe(CN)_6$ were found valuable for developing the tungstides. Heat tinting could also be used.

4. The nomenclature of the constituents of carbon steels is applicable to the constituents of high speed steels.

5. The embedded globules in high speed steel are of a complex but similar chemical composition, and should be designated as tungstides.

6. The tungstides are of a eutectic composition.

7. Iron-dissolving chromium has a greater power to dissolve the tungstides than iron alone.

8. The distribution of the tungstides depends upon the size of the ingot and the casting temperature as well as the amount and manner of reduction given the steel from the ingot to the finished bar.

SELECTION OF STEELS FOR AUTOMOBILES

By W. E. Jominy

ONE of the fundamentals of successful automobile construction lies in the proper selection of materials. However good the design may be otherwise, failure often results through the improper selection of materials by the designer. In this paper, the selection of steels for automobiles will be considered. Questions of fabrication and design will be considered only as they affect this. The subject has been divided into two main parts. The first part is a consideration of the various factors governing the proper selection of a steel for a given part. The second part is a discussion of the steels most commonly used in present day practice, giving the relative merits of each.

The kind of steel used in any automobile part depends largely upon its design. Lightness, distribution of metal, rigidity, ample radii at corners, tendency toward warping, all of which are embraced in the design of a part, largely control the steel which shall be chosen for the part. For example, most manufacturers use a high grade alloy steel for the rear axle shafts, yet there is a prominent maker of a medium grade automobile who uses ordinary open-hearth plain carbon steel for this part. Again there is a well known low priced car, which has heat treated alloy steel connecting rods, while most manufacturers use heat treated plain carbon steel, and one high grade manufacturer uses annealed plain carbon steel for his connecting rods. Obviously there is a great difference in the physical properties developed in these steels, but in any of the cases just mentioned, it is unlikely that the wrong material has been chosen. The differences in materials are largely the result of the different designs. There are a great many other considerations besides design in selecting the proper steel for a given part, but it is necessary first to know approximately what physical properties are required before any intelligent selection can be made. There are relatively few automobile parts in which the stresses can be figured accurately, but in many cases an approximate figure can be obtained. The required ductility for any part cannot be figured in any way, and for this reason there is much conjecture about this property, which is equally as important as the elastic limit of the steel.

Many engineers pay little attention to the ductility required in any given part, and investigate only the elastic limit required. It should be emphasized that the ductility of a steel is equally as important a property as its elastic limit and that failures occur just as quickly, in fact usually more quickly, when the ductility is too low than when the elastic limit is too low. The minimum ductility required for any part must be determined by the cut and try method, since there is no way of calculating it. Fortunately for parts of like function the minimum ductility required is about the same, so that once determined it can be applied generally. For example, the leaves in a chassis spring should have an elongation of about 9 per cent or better and a reduction of area of about 28 per cent or more to function satisfactorily; and whether the spring is lightly stressed or heavily stressed, or whether

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it is used on a light touring car or heavy truck, the same minimum elongation is required.

To choose the proper steel for a given part then, we will first decide what minimum elongation and reduction of area it will be necessary to maintain, and then select those steels which, when heat treated to give an elongation over the minimum required, will give the desired elastic limit. Usually there will be half a dozen or more steels which will answer our purpose. If the part is subjected to large alternating stresses it may be expedient to further limit the possible number of steels for a given part by choosing those having high Stanton values and high impact values. Even limited in this way there will probably be several steels usable for any part from which must be chosen the most economical one to use.

In many cases properties other than structural are required, such as resistance to wear, resistance to burning, high tensile properties when hot, magnetic permeability, resistance to corrosion, etc. The same method of choosing steels for these parts can be used as mentioned above; the additional properties required simply limit the number of steels from which we must choose the most economical.

The most economical steel is not necessarily the one with the lowest first cost, although this is a consideration along with the ease with which the steel can be forged, burned, annealed, heat treated, warped, straightened and machined. Ability of the mill to consistently produce the steel free from pipes, seams and the many inherent defects, as well as possible sources of supply all enter into the problem. These qualities are not easily ascertained and require careful study of their use on a production scale. Experiments carried out on a production scale introduce so many variables that it is difficult to arrive at accurate results. The large difference in shop methods, as well as the differences in the number of cars produced per day, are perhaps the main reason why all shops are not unanimous in the choice of one type of steel.

Chrome-nickel, straight nickel, chrome-vanadium and recently chrome-molybdenum steels each have their staunch supporters, and undoubtedly each excels the others under certain conditions. For any given shop there is generally one steel which proves most economical, and the tendency is to use this wherever possible. This tendency should not be criticized, because it is desirable to use as few steels as possible in a plant. A reduction in the number of steels used means a reduction in the heavy investment an automobile manufacturer has in his stock of steel. It also makes for better purchasing conditions, better production conditions and less chance for mixing steels. Summing up the manufacturer's metallurgical problem, we find that he wishes as few different steels as possible which will meet his shop conditions economically and possess physical properties to satisfy the requirements of his many parts.

Having these requirements in mind, the following list of steels has been drafted and is intended to cover the needs of a manufacturer who is making all his parts at his own plant. Only the relatively important parts are mentioned, but these steels should take care of all parts.

(1)—A steel for sheets and strips of average importance. This is usually an open-hearth 0.10 per cent carbon steel, the same as S. A. E. No. 1010. It is used for fenders, body plates, splashers, hoods and various stampings. It is finished in most any degree of smoothness desired

and annealed in various ways to produce ordinary or extra deep drawing qualities.

(2)—A good machining steel for ordinary bolts, nuts, screws, studs and many other parts which are lightly stressed. A cold rolled or drawn bessemer steel of carbon content about 0.08 to 0.16 per cent, corresponding to S. A. E. No. 1112, is generally used. More attention is paid to the machinability of this steel than its strength. It is not considered a good carburizing steel, although it is used for this purpose by some makers of low priced cars. Because of its easy machining qualities it is popular with men in charge of production work.

(3)—A plain carbon carburizing steel for such parts as camshafts, tappets, spring bolts, water pump shafts, front end gears, etc. Following is the most common steel used for these parts:

	Per cent
Carbon	0.15—0.25
Manganese	0.30—0.60
Sulphur	0.050 maximum
Phosphorus	0.045 maximum

This steel is easily forged and machined although its machining qualities are not as good as steel (2) given above. After carburizing it is necessary to water quench this steel to produce a scleroscope hardness of 75 or more. If the steel is properly heat treated the Brinell hardness of the core will not exceed 200. It is not customary to refine the grain of the core of camshafts, tappets or water pump shafts. In the case of tappets and water pump shafts it is not deemed necessary and in the case of camshafts too much warpage is induced. Some makers use a steel ranging in carbon from 0.10 to 0.20 per cent for these parts. Better ductility results from the use of this steel but it is more difficult to machine.

(3-*a*)—Stampings, parts made from seamless tubing and frames are made from the same analysis steel given under (3). Frames also are quite commonly made from a 0.20 to 0.30 per cent carbon steel, other elements the same as under (3).

(4)—A forging steel of medium carbon for parts not too highly stressed, commonly used for connecting rods, crankshafts, front axles, spring clips, brake levers, etc. Many manufacturers use alloy steels for some of these parts and, as previously stated, the design largely determines which steel must be used. The medium carbon steel, however, is the most economical steel for these parts and if the design permits this steel will be used. If the design requires steels of higher physical properties some of the alloy steels which will be discussed later can be used. Following are the steels generally used in this group:

	(a) Per cent	(b) Per cent
Carbon	0.30—0.40	0.35—0.45
Manganese	0.50—0.80	0.50—0.80
Sulphur	0.050 maximum	0.050 maximum
Phosphorus	0.045 maximum	0.045 maximum

Both of these steels forge easily, respond well to heat treatment and are fairly easy to machine. Unless the sections are very irregular water may be used as the quenching medium. The Brinell hardness to which these parts are usually held depends again upon their design, but it will be found usually that when made from this steel connecting rods will

have a hardness somewhere between 190 and 290, crankshafts between 217 and 290 and front axles between 190 and 260.

(5)—A spring steel for coiled springs, lock washers, etc. This steel will have the following analysis:

	Per cent
Carbon	0.58—0.70
Manganese	0.70—1.00
Sulphur	under 0.050
Phosphorus	under 0.045

Where the size is suitable, coiled springs generally are coiled from wire of this analysis which has been tempered at the mill. After coiling, the springs are given a low draw at about 500 degrees Fahr. to remove the coiling strains and used in this condition. Whether tempered at the mill or heat treated at the spring plant, satisfactorily coiled springs will have a scleroscope hardness between 55 and 70.

(6)—A steel for keys, coiled springs of thick wire and ball bearing balls. Following is the steel generally used here:

	Per cent
Carbon	0.90—1.05
Manganese	0.25—0.50
Sulphur	under 0.045
Phosphorus	under 0.040

This steel is also used in low priced cars for chassis springs.

(7)—An alloy carburizing steel for parts where resistance to high stresses as well as wear is a factor, as case hardened gears, piston pins, steering knuckle pins, differential crosses, ring gears, ball bearing races, etc. Here we find a diversity of opinion as to the steel required. The following steels are most common:

	(a) Per cent	(b) Per cent	(c) Per cent	(d) Per cent	(e) Per cent	(f) Per cent
Carbon	0.10—0.20	0.15—0.25	0.15—0.25	0.15—0.25	0.15—0.23	0.08—0.16
Manganese	0.50—0.80	0.50—0.80	0.50—0.80	0.50—0.80	0.30—0.60	0.30—0.60
Sulphur	0.045 max.	0.045 max.	0.045 max.	0.045 max.	0.045 max.	0.045 max.
Phosphorus	0.040 max.	0.040 max.	0.040 max.	0.040 max.	0.040 max.	0.040 max.
Chromium	....	0.45—0.75	0.80—1.00	....	1.00—1.20	1.00—1.20
Nickel	3.25—3.75	1.00—1.50	....	3.25—3.75	3.00—3.50	3.00—3.50
Vanadium	....	....	0.15—0.20	....	....	....

Steel (*a*) is easy to heat treat and gives highly satisfactory results, producing a very ductile core. Unless carefully prepared, however, it is rather difficult to machine.

Steel (*b*) machines a little easier than (*a*), but does not give quite as ductile a core.

Steel (*c*) is a good carburizing steel, but due to the increasing cost of vanadium, the steel has a rather high first cost.

Steel (*d*) is easier to machine than (*a*) but does not give quite as ductile a core and requires a little more care in heat treatment.

Steel (*e*) requires careful heat treatment to produce a soft core and a hard case, and several concerns have not been able to use it successfully on a production scale. When properly heat treated, however, this steel has good physical properties, and has been the salvation of some otherwise impossible designs.

Steel (*f*) gives excellent physical properties and is much easier to heat treat than steel (*e*). Where heat treating difficulties are encountered,

steel (*f*) is often substituted to advantage for (*e*). Steel (*f*), however, is more expensive than (*e*).

All of these steels can be hardened to a scleroscope hardness of 75 minimum, using oil as a quenching medium, in fact, many manufacturers require a minimum of 80. Water can be used as a quenching medium for steels (*a*), (*b*), (*c*) and (*d*) for some sections, but because mininum warping is desired oil is generally used. Nearly all parts made from those steels are double quenched. An exception to this is the ring gear, which is seldom double quenched because the high heat to refine the core produces too much warping.

(8)—A steel for the usually high stressed parts such as rear axle shafts, steering knuckles, propeller tubes, steering arms, connecting rod bolts, highly stressed studs, etc. Where design makes it necessary, front axles, spring clips and connecting rods are also made from this steel. Here there is a wide range of steels used:

	(a) Per cent	(b) Per cent	(c) Per cent	(d) Per cent
Carbon	0.25—0.35	0.25—0.35	0.25—0.35	0.30—0.40
Carbon	0.30—0.40	....	0.30—0.40	....
Carbon	0.35—0.45	....	....	....
Manganese	0.50—0.80	0.50—0.80	0.50—0.80	0.30—0.60
Sulphur	0.045 max.	0.045 max.	0.045 max.	0.045 max.
Phosphorus	0.040 max.	0.040 max.	0.040 max.	0.040 max.
Chromium	0.45—0.75	0.80—1.10	....	0.60—0.95
Nickel	1.00—1.50	....	3.25—3.75	2.75—3.25
Vanadium	....	0.15 min.	....	....

Where different carbon ranges are given it should be remembered that the lower the carbon content the easier the steel is to forge, anneal, machine and heat treat but also the lower the carbon the lower the physical properties of the steel.

Steel (*a*) is a popular steel. It forges rather easily, is not difficult to anneal, responds well to ordinary heat treatment, although in general requires oil quenching, and gives good physical properties.

Steel (*b*) forges easily, is easy to anneal, is easily heat treated and far less sensitive of over heating than (*a*), (*c*) or (*d*). It can be quenched in water and gives good physical properties. Due to the high cost of vanadium, the first cost is rather high and because of higher heats required to treat it, is a little harder on the furnaces.

Steel (*c*) is rather easily forged, is not difficult to anneal or heat treat, but the hardness does not penetrate well in large sections. In small sections it gives satisfactory physical properties. This steel also seems to have more inherent defects than the others.

Steel (*d*) is rather difficult to forge, difficult to anneal, requires careful heat treatment but gives excellent physical properties. Usually when steel (d) is used in a manufacturer's plant it is because of some one particular part and he makes all his other parts in this group out of steel (*a*), (*b*) or (*c*).

Chrome-molybdenum steel has been introduced recently as an automobile steel with what seems to be a promising future. At the present time, however, it has not been sufficiently used in quantity production to include it in our list.

(9)—A steel for gears. This function requires all that we can get from a steel. We must have resistance to wear, to shock, and to very high stresses. There are still quite a number of cars made with carburized gears and in this case one of the steel under (No. 7) is used. The general con-

sensus of opinion seems to be, however, that all things considered, the oil hardened gear is more satisfactory. The following are the more common steels:

	(a) Per cent	(b) Per cent	(c) Per cent
Carbon	0.45—0.55	0.40—0.50	0.45—0.55
Carbon	0.40—0.50	....	0.40—0.50
Manganese	0.30—0.60	0.50—0.80	0.50—0.80
Sulphur	0.040 max	0.045 max.	0.040 max.
Phosphorus	0.040 max.	0.040 max.	0.040 max.
Chromium	0.60—0.90	....	0.45—0.75
Nickel	1.50—2.00	3.25—3.75	1.00—1.50

Steel (*a*) is difficult to forge, difficult to anneal, hard to machine, must be heat treated with great care but gives excellent results. The steel with the lower carbon range eases these difficulties.

Steel (*b*) is a little easier to forge and anneal than steel (*a*) but in large sections the hardness does not penetrate as well as in the other steels. It does not have physical properties as good as (*a*).

Steel (*c*) is somewhat easier to forge, anneal and machine than (*b*) and has about the same physical properties.

Gears made from these steels and heat treated to a scleroscope hardness of 70 to 75 seem to give the best results.

(10)—A steel for chassis springs. We have already discussed the plain carbon steel that is used for lightly stressed springs. There are three other steels which are commonly used which have the following analysis:

	(a) Per cent	(b) Per cent	(c) Per cent
Carbon	0.45—0.55	0.40—0.50	0.65—0.75
Manganese	0.60—0.80	0.80—1.00	0.85—1.05
Sulphur	0.045 max.	0.040 max.	0.035 max.
Phosphorus	0.045 max.	0.040 max.	0.035 max.
Silicon	1.80—2.10	....	0.30 max.
Chromium	....	1.05—1.20	0.30—0.45
Vanadium	....	0.15 min.	....

These steels all give good results. Steel (*c*) is generally conceded to be the best of these three, but it is more delicate and consequently more difficult to handle than the other two. The hardness of the spring leaves should be as close to 400 Brinnell as is commercially possible to maintain.

(11)—A magnet steel. The following analysis is common for this purpose:

	Per cent
Carbon	0.80—0.90
Manganese	0.30—0.50
Silicon	0.25—0.40
Chromium	1.90—2.10
Tungsten	0.75—1.00

(12)—A valve steel. Strength, resistance to wear and resistance to scaling at elevated temperatures characterizes a good valve steel. Most of the lower priced cars have valves made from a cast iron head cast or welded onto a machine steel stem. These valves resist scaling at high heats, quite satisfactorily but warp and pit easily. If better materials are required one of the following steels should prove satisfactory:

	(a) Per cent	(b) Per cent	(c) Per cent	(d) Per cent	(e) Per cent	(f) Per cent
Carbon....	0.25—0.35	0.50—0.70	0.50—0.70	0.20—0.40 or 0.40—0.50	0.40—0.50	1.20—1.50
Manganese	0.50—0.80	0.30 max.	0.30 max.	0.050 max.	0.30 max.	0.20—0.30
Sulphur...	0.045 max.	0.035 max.	0.035 max.	0.035 max.	0.030 max.	0.035 max.
Phosphorus	0.040	0.035 max.	0.035 max.	0.035 max.	0.030 max.	0.035 max.
Silicon.....	....	....	....	....	3.50—4.50	0.40—0.60
Chromium.	....	0.50—1.00	3.00—4.00	11.50—14.00	8.00—10.00	11.50-13.00
Nickel.....	3.25—3.75	....	....	3.00 max.	....	0.40—0.60
Tungsten..	....	1.50—2.00	13.00-15.00	....	....	....
Cobalt....	....	....	....	....	....	3.00—3.50

The principle merit of steel (*a*) is in its relative cheapness. It is easier to forge and machine than the other steels in this group and has the lowest first cost. It does not resist scaling well but will not warp as easily as the cast iron head valve.

Steel (*b*) costs a little more than steel (*a*) but is a little stronger at high temperatures and so resists warping better.

Steel (*c*) is the strongest steel of the group at high temperatures, 1200 to 1700 degrees Fahr. and for this reason has the highest resistance to warping.

Steel (*d*) is not as strong at high heats as (*c*) but resists scaling much better. For this reason (*d*) under most conditions is better than (*c*).

Steel (*e*) resists scaling a little better than (*d*) but is otherwise about the same.

Steel (*f*) resists scaling as well as (*d*) and is nearly as strong as (*c*) at high temperatures. It is about the best valve steel we have today which has been used on a production scale.

These 12 steels cover every need of the automobile engineer in designing a motor car. It has been necessary to be extremely brief in discussing each of these steels in order to cover them all. If a manufacturer makes every part of his automobile at his own plant, he will require a minimum of 12 steels, and if he uses cast iron head valves, he can cut down to 11. Under present conditions, this is the minimum number of steels from which an automobile can be built on a production scale. No manufacturer makes all parts for his automobile at his own plant, yet it is not at all uncommon to find 20 or more different steels in his stock. While it may not be possible for him to get down to a minimum of 12 steels, he should be able to get along with much less than 20. In these times of retrenchment and economy, it might be well for the manufacturer to consider the opportunity of large saving by reducing the number of steels in his stock.

HIGH PRESSURE GAS AND ITS APPLICATION TO INDUSTRIAL FURNACES

By F. J. Evans

EQUIPMENT that harnesses and regulates heat efficiently is comparatively new. Less attention has been given to "heat process management" than to the mechanical processes. Today, the cost of fuel and product requirements make heat engineering a vital phase of management.

The past few years have found the steel industry in the slow process of readjustment from conditions imposed by the war. Many furnaces used for war work have passed out of existence although in a few cases, certain of them have been adapted to other purposes. Beyond doubt, many manufacturers have had their attention drawn in such forceful ways to furnace design and furnace efficiency, and to methods for heating furnaces that the lessons learned will be of permanent value.

The attitude of manufacturers toward unfamiliar methods is not, as a rule, to their credit. They seem regrettably unwilling to follow the recommendations of their own engineers, also to hold the latter so rigidly responsible that nothing short of absolute certainty of success will induce the engineer, often an expert in his line, to make a recommendation. The lack of fuel experts, upon the engineering staffs of many large concerns is often noticeable.

In the treatment of steel it is important to heat the steel uniformly, and at a definite rate according to the particular operation. The work must be placed in the furnace so that all parts may become thoroughly and evenly heated for variation in the furnace temperature or uneven heating will invariably produce nonuniform results. Thus it is at once apparent that the temperature and atmospheric conditions of the heating zone of the furnace are of utmost importance. There are several factors which tend to influence this condition, the most essential of which are the kind of fuel used and the methods of its application. Since practically all fuels require a certain amount of free oxygen to support combustion, it is obvious that the best results will be obtained, all things being equal, with the fuel that will admit of an automatic means of proportionally mixing the oxygen with the fuel.

Coal, coke and oil by reason of their physical properties are not well suited for mixing automatically with air in the proper portions for complete combustion. Since all fuels except carbon must reach a gaseous state before combustion really takes place it is obvious that commercial gas of the proper composition and heating value would be the logical fuel to use.

In the combustion of any fuel it has long been the object of fuel engineers to effect complete combustion with a minimum amount of excess air, which obviously wastes a certain percentage of the heat. Any air beyond that amount required to completely burn a given quantity of fuel is not only unnecessary but is harmful in two ways; it carries off an amount of heat, depending upon the temperature of the flue gases, and it lowers the temperature below the maximum temperature obtainable when the fuel is burned with no excess air.

It has been only within the past several years that the properties of perfectly proportioned mixtures of air and gas have been well understood and the development of any practical process or apparatus capable of operating

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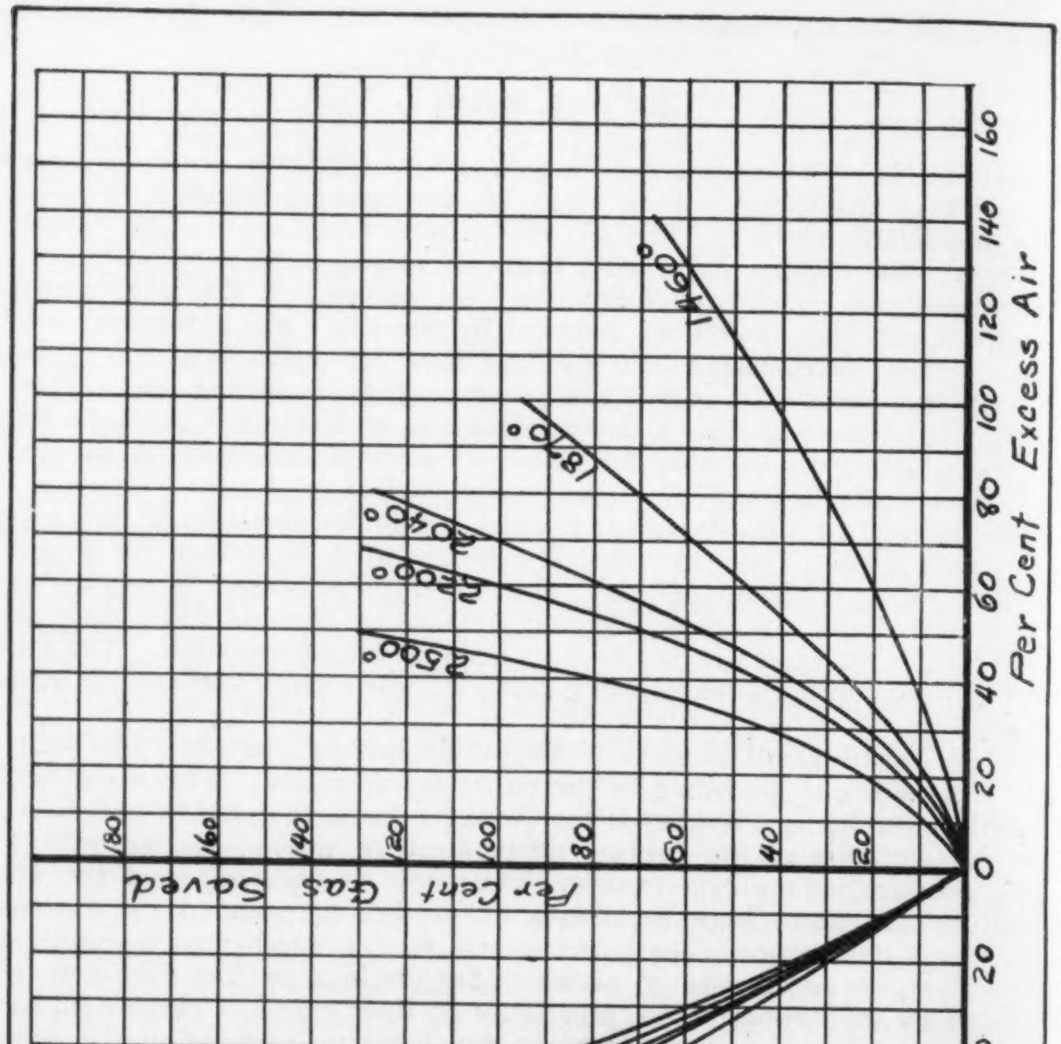


Fig. 1—Gas saved by correct proportioning in percentage of gas consumed with correct proportioning

on such mixtures has been accomplished. Further, the operator of any appliance usually has neither the inclination nor the ability to make manually the proper adjustments to secure the best mixture. It is therefore, quite usual for furnaces, under shop conditions, to run with 30 or 40 per cent excess air and many show a far greater percentage. Not infrequently the excess air content in the flue gases is accompanied by carbon monoxide which shows incomplete combustion. This condition results from stratification in the mixture stream and can only be corrected by obtaining a homogeneous mixture, that is, to have every particle of combustible in intimate contact with its combining proportion of oxygen. When this stratification occurs the generation efficiency is still further lowered, depending of course, on the percentage of oxygen and carbon monoxide found in the waste gases.

As a result of years of experience and experimenting to obtain the most economical and practical application of efficient combustion to the various heating operations which are encountered in the present industries, equipment has been produced which is essentially a mechanical application of engineering principles of combustion based upon discoveries developed through years of scientific research by some of the most eminent fuel engineers in this and other countries.

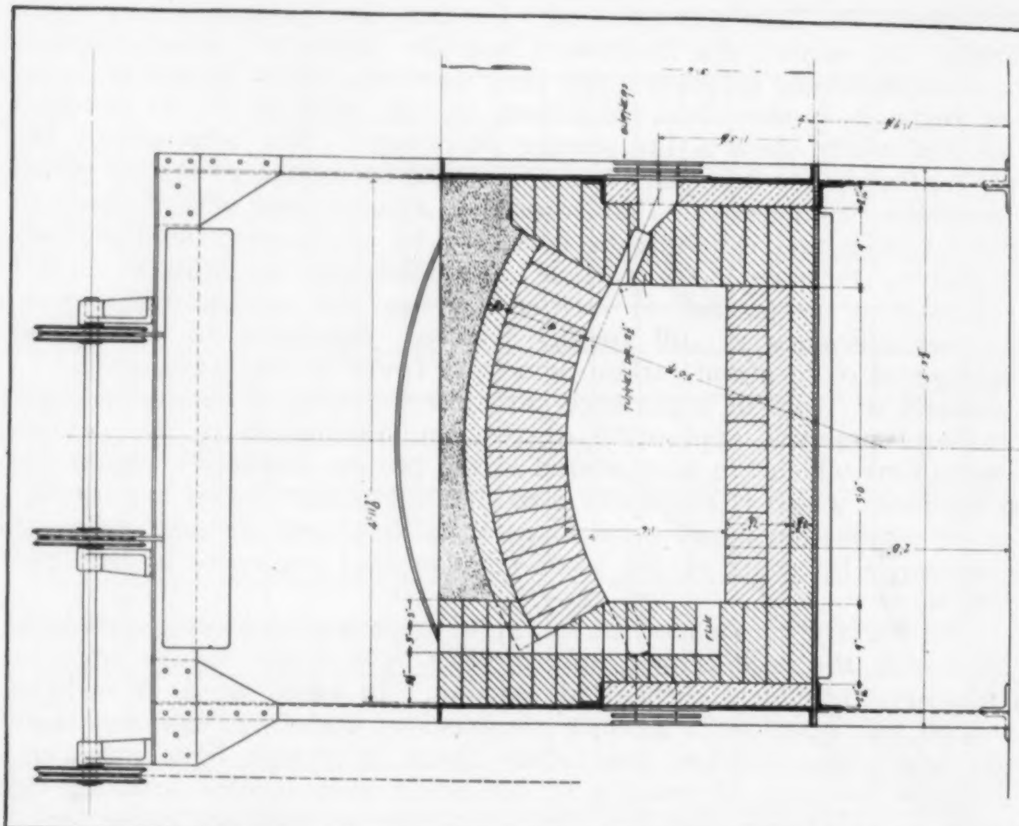
The term surface combustion in so far as it relates to heating problems merely refers to the well-known influence of light wave energy upon a gaseous mixture to accelerate chemical reaction. In other words it is light catalysis upon gas reactions. Surface combustion, therefore, can and does take place in any gas reaction zone where there is enough light wave energy to increase the speed of reaction by ionization of molecules, breaking up of molecules or otherwise changing their condition to facilitate more rapid readjustment.

In the application of a gas fuel to industrial plants three distinct systems are in common use:

1. Low-pressure air and gas system with two valve control and manual proportioning
2. Low-pressure air and gas system with single valve control and automatic proportioning
3. High-pressure gas system with single valve control and automatic proportioning.

Under the first system the efficiency of the furnace is at the mercy of three variables, namely, air pressure, gas pressure and the skill of the furnace operator. It is obviously unreasonable to expect that even a commercial degree of accuracy can ever be obtained with these three variable conditions. With the best of conditions it is impossible to avoid fluctuations in pressure of the gas and air supplies which must result in an impaired furnace atmosphere that may become oxidizing and therefore detrimental to the steel being treated, causing scale formation or it may become excessively reducing with an accompanying waste of fuel.

The losses occurring on account of these three variables are best illustrated by the curves shown in Fig. 1, published in the 1921 proceedings of the American Gas Association, showing the amount of fuel wasted at the various temperatures in a furnace due to improper proportions of air and gas expressed in percentage of the amount of fuel consumed in the furnace at the given temperatures with correct proportions of air and gas. These curves were derived by actual tests run on a small oven-type furnace. The fuel consumption required to maintain the furnace at the various temperatures was



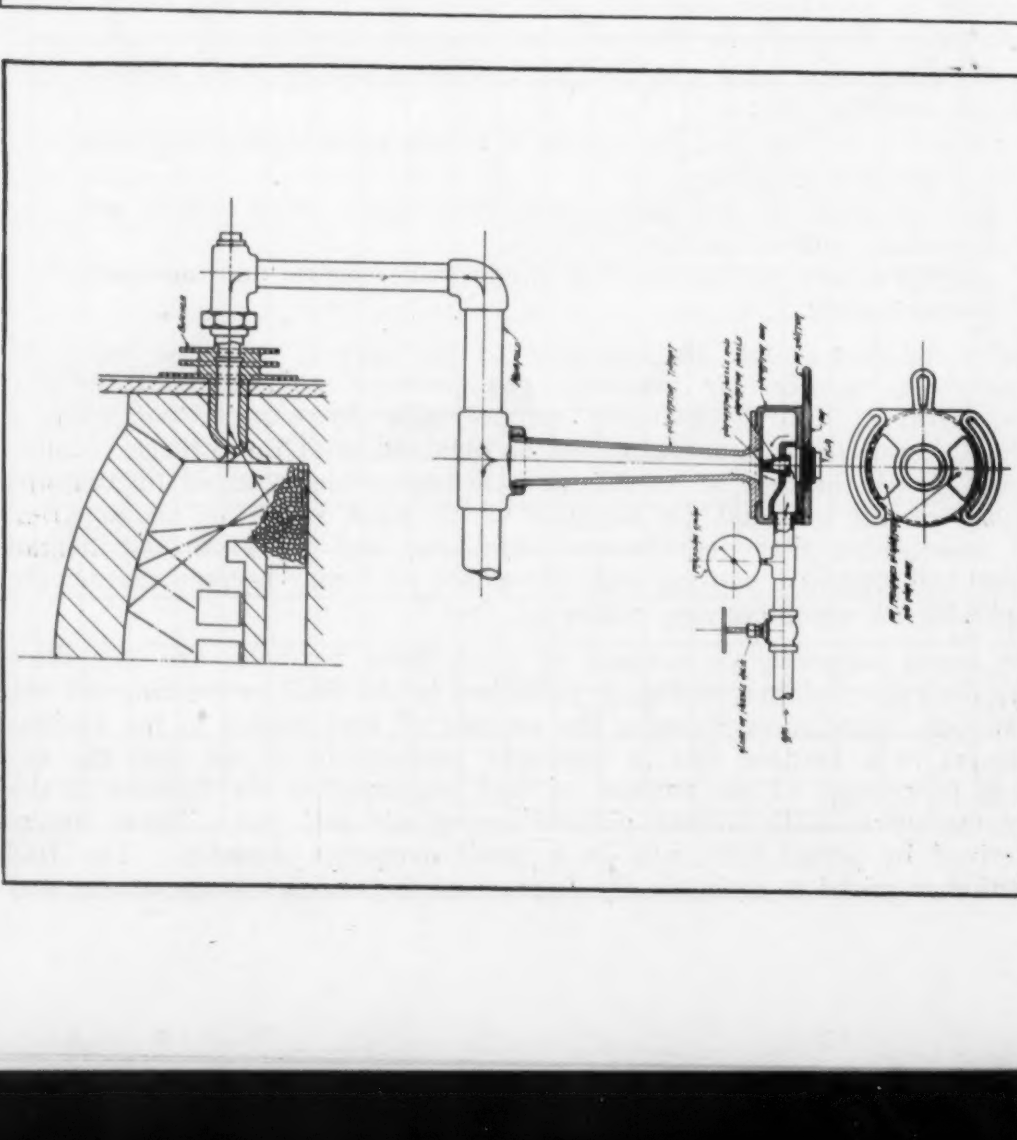


Fig. 2—(left) Diagram showing essential components comprising a high-pressure gas burner equipment. Fig. 3—(right) General design and construction of one type of furnace. See Fig. 5

first determined with a correct mixture and then with mixtures of various percentages of excess air and gas, and it will be noted that the losses greatly increase with the furnace temperature. For example: At 2500 degrees Fahr. and with 49 per cent excess air, the gas consumption was actually 360 cubic feet while with correct mixture the consumption was only 163 cubic feet. Therefore the gas saved by correct proportioning in percentage of the consumption with a correct proportioning would be $\frac{(360-163)\,100}{163}=121$ per cent as shown on the curve.

In both the first and second systems, the entire plant must be piped with large size pipes for both air and gas. An 8-inch pipe carrying gas under 10 pounds pressure would replace a 20-inch pipe distributing gas at the low pressures normally used. Low-pressure air cannot be piped efficiently for any great distance, thereby necessitating placing of individual blowers for each shop.

The third or high-pressure gas system eliminates all of the disadvantages. It is called the high-pressure system because the gas is delivered under pressure to the furnaces, the pressure required varying with the gas used. One and one-half ounces per square inch is satisfactory for blast-furnace gas, while 8 ounces to one pound will suffice for producer gas. Coke oven gas can be used at from 3 to 10 pounds, and natural gas at from 20 to 40 pounds pressure.

In many cases the gas to be used is available at the required pressure. When such is not the case a compressor is installed. The high-pressure gas entering the furnace equipment is projected through a nozzle into the throat of a venturi entraining tube. Flow energy, or inertia of the gas, causes the entrainment of the air necessary for combustion from the atmosphere. Proper selection of the gas nozzle will enable the production of a perfect mixture, or of one which is rich or lean, as may be desired. When the desired setting has once been made, the proportion of air and gas will remain true and constant throughout the range of the apparatus, which is usually about 4 to 1. The mixture becomes homogeneous at about the time it leaves the entraining tube to enter the manifold. This system does away with the necessity for air under pressure and the consequent air piping. The salient features of the high-pressure system are:

1. The absolute unvarying gas pressure in the pipe lines to the furnace, irrespective of the pressure conditions at the gas holder or the number of furnaces in use at any one time.
2. The maintenance of any constant homogeneous ratio of gas to air is supplied through the burners at all times and through all rates of furnace operation.
3. Highest quality of production—temperature and furnace atmosphere are controlled unvaryingly even by the most unskilled labor.
4. Daily reproduction of heating conditions with absolute certainty and without recourse to burner adjustment.
5. Highest possible combustion efficiency.
6. Highest possible output with minimum fuel consumption.
7. Gas compressor unit entirely automatic, reliable and economical.

The above are some of the more important advantages offered by the use of the high-pressure gas system, the realization of which is entirely de-

pendent upon the equipment used to deliver and maintain the proper and constant pressure of gas in the distribution lines to the furnaces and upon the proper application of equipment for heat generation.

The following points are of prime importance for satisfactory operation of any high-pressure gas burner equipment:

1. Operating characteristics of the equipment:

(a). Under this consideration it is necessary to appreciate that correct mixtures of air and gas are explosive and, therefore, require the greatest care in handling. The essential components which comprise a high-pressure gas burner equipment are the inspirator or automatic proportioning device, the burner through which the mixture is delivered into the fur-

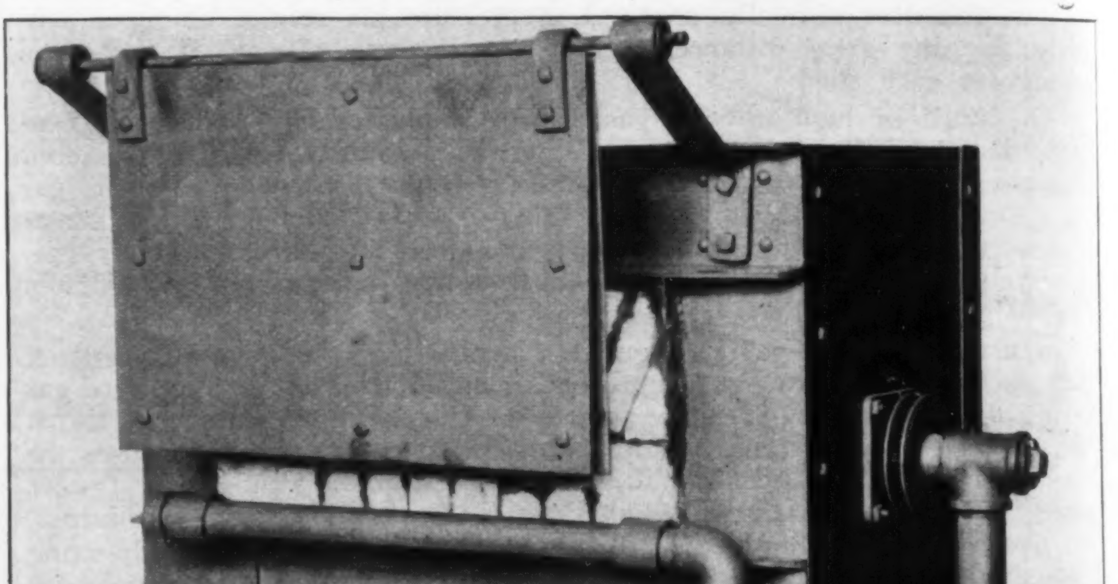


Fig. 4—A small standard furnace completely equipped

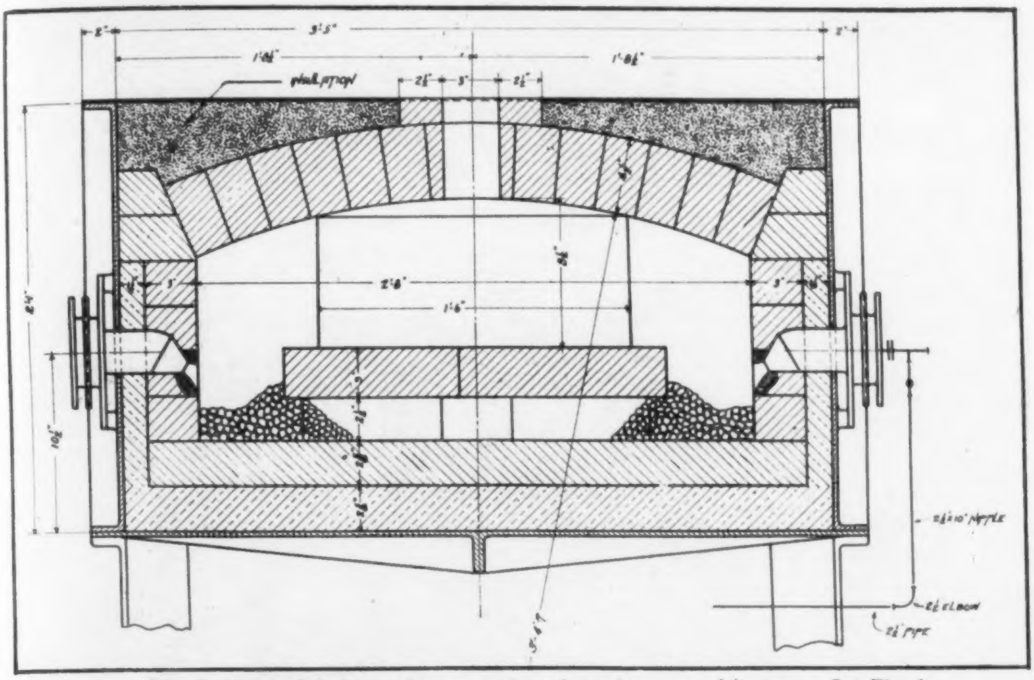


Fig. 5—General design and construction of another type of furnace. See Fig. 3

nace, the pressure gage and control valve and the manifold piping connecting all of these elements as shown by the drawing in Fig. 2. The photograph shown as Fig. 4 illustrates a small standard furnace completely equipped. Each inspirator must be designed and constructed so as to mix homogeneously the air and gas. Unless the entire equipment is aligned in certain proportions this will not be accomplished and incomplete combustion will result.

(b). The inspirator must have a high mechanical efficiency or in other words a wide range of regulation. One of the precautions against back-firing is in maintaining the pressure on the mixture at the burners well above that which permits the mixture as discharged at the burner to slow down to a velocity near the rate of flame propagation. There are numerous types of inspirators on the market which will draw in the proper proportion of air and maintain this pressure, but which do not give any range of regulation. In order to secure range of control the attempt is made often to install a large number of burners in a furnace, all of which burners operate at one fixed rate, and then to shut off such burners as may be found at certain rates of operation are not required. This necessarily calls for a complicated system of controls and will inevitably produce uneven heating when the furnace is being operated with some of the burners shut off as well as cause those burners which are not in operation to melt or burn off.

(c). The manifold piping, arrangement and size must be so designed as to prevent back-firing and to maintain the pressure head built up by the inspirator.

(d). Construction of the burner must be of a type which will

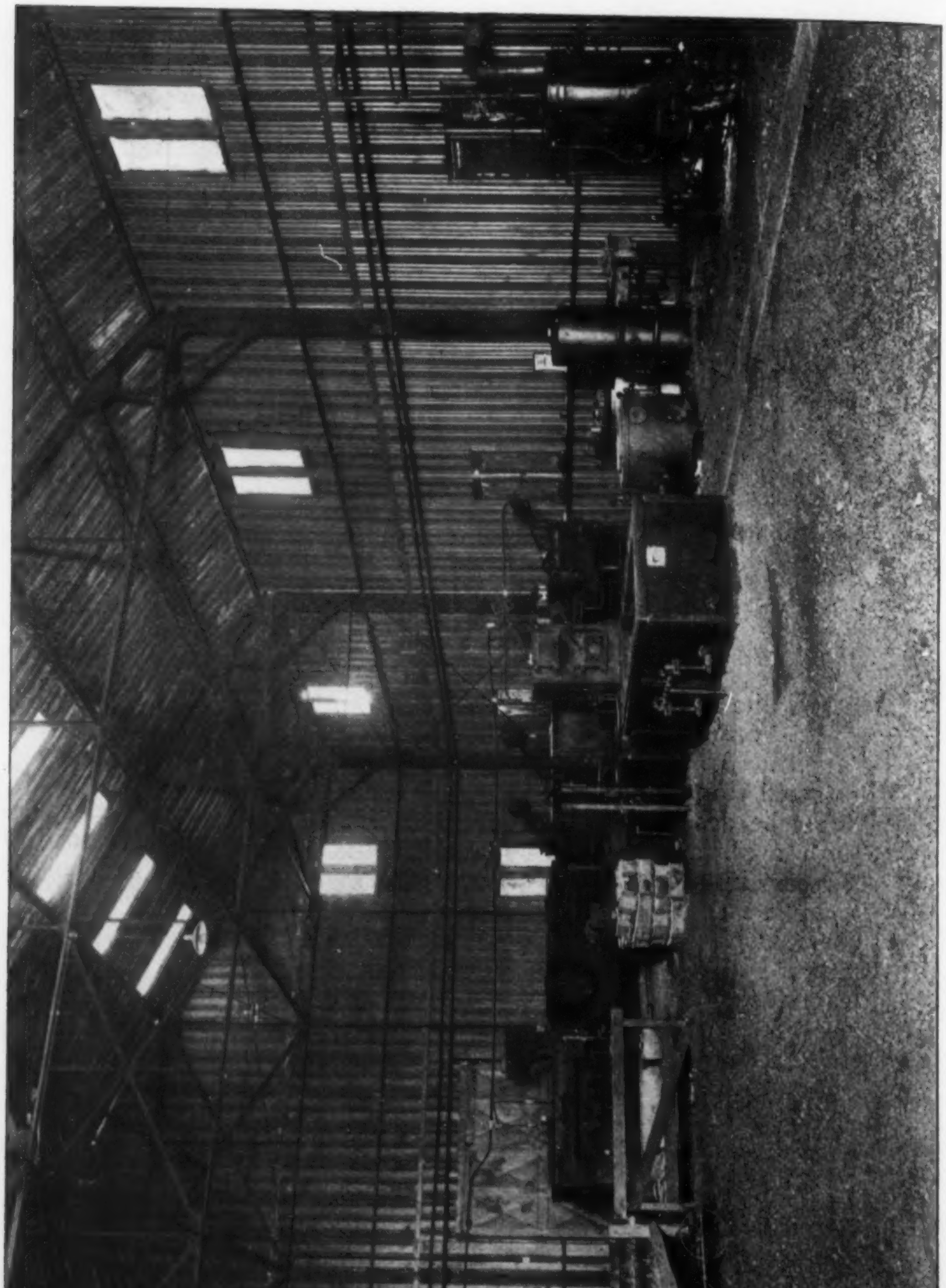


Fig. 6—Commercial heat treating plant completely equipped with high pressure gas system. Note absence of large and cumbersome piping

prevent over-heating and consequently destruction of the burner tip. This is not only an expensive item in cost of repairs but is also one cause of back-firing. Burners used with one well-known equipment are of a patented self-cooled type of a simple cast iron construction. Some of these burners have been in daily operation in steel welding furnaces for over three years without indications of burning out.

(e). On furnaces requiring equipment of such size that possible back-firing would be dangerous it is imperative that the

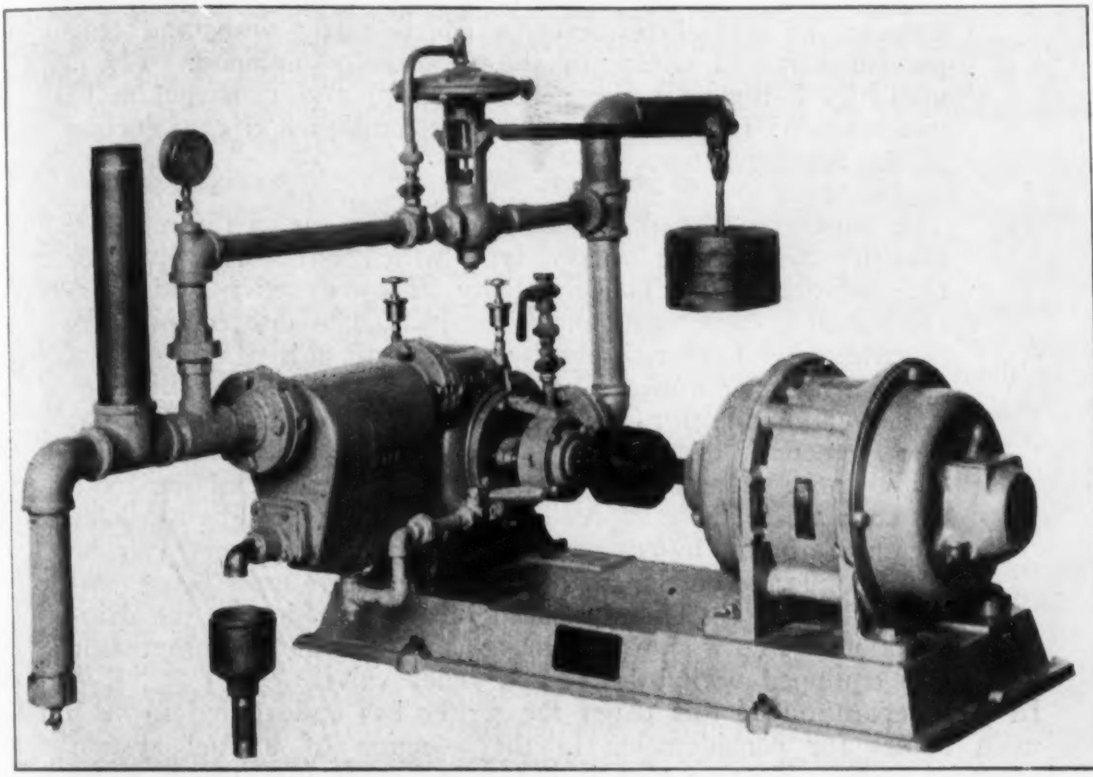


Fig. 7—A direct connected motor compressor unit equipped with by-pass and relief valve

equipment supplied should absolutely eliminate the possibility of back-firing.

2. Arrangement of the burners:

(a). Burners must be so arranged that equipment on each furnace is easily and simply controlled. Location of the burners depends upon the type of heating operation.

(b). Number and size of the burners depend upon the shape and size of the heating chamber as well as upon the amount and temperature of the work to be treated.

3. Size and shape of the combustion chamber in the furnace:

(a). In determining the size and shape of the combustion chamber of any furnace it is, of course, necessary to design this chamber in proportion to the amount of fuel to be consumed as determined by the amount of work to be treated. Dimensions of the heating chamber are also determined from

the same factors. Through experience gained from practice and research a definite and working ratio has been established for the cubic feet of gas consumed per hour to the square foot of internal heating surface for all types of furnaces.

4. Nature of the refractories:

(a). Certain sections of all furnaces fired by a homogeneous mixture of air and gas are subjected to much greater deteriorating effects than others regardless of the evenness of heating.

(b). The location of these heating zones is controlled by the proper design of equipment and these zones are then constructed of special refractories which easily withstand temperatures far in excess of those normally obtained. Fig. 3 and Fig. 5 illustrate the general design and construction of two types of furnaces as well as the location and construction of the heating zones.

5. Compressors:

(a). The compressors used for compressing the gas to the required pressure are of the rotary type which have no valves or reciprocating parts. The simplicity of construction and operation makes these units most reliable. The desired pressure is maintained automatically by means of a bypass equipped either with an automatic relief valve or with a patented unloader, and therefore can be operated by unskilled labor. The large units are equipped with the special unloader which employs the venturi principle to raise the pressure of the fresh gas supplied to the compressor by making use of the available pressure of the by-passed gas. These compressors can be direct connected on the smaller units, the large units being connected by a silent chain encased in an oil casing to the driving motor. Fig. 7 shows a direct-connected motor compressor unit equipped with by-pass and relief valve.

In the preparation of this paper the writer has endeavored to set forth the main points for consideration in the selection of a fuel system for an industrial plant. Heating cost is dependent upon the correct utilization of the fuel and is not wholly determined by the fuel cost. Therefore, the man who continues to draw his conclusions from results secured in the past by the use of obsolete or poorly designed equipment cannot choose wisely, and the many successful installations now in operation have proven that with modern methods and improvements gas used efficiently is an ideal industrial fuel capable of meeting keen competition with the other fuels or heating mediums.

THE FIELD OF RESEARCH IN INDUSTRY

By Edward P. Hyde

THE comprehensiveness of this paper reminds me a bit of the comprehensiveness of the name of a little hotel in Paris. The hotel was called, as a big sign across the front proclaimed, "Hotel de l' Univers et de Portugal," and I used to wonder why Portugal was considered "ex universa" and had to be added. Some time afterwards I observed at the bottom of the sign in small letters the explanatory word "reunis." In a somewhat similar way I should have several sentences in small letters explaining that it is not my intention in this paper to endeavor to cover the whole scope of possible research, and to fit every part of it into its appropriate nook and corner. The schematic chart, shown in the accompanying illustration, is introduced here simply to show what place research in industry takes in the general scheme, as the problem is analyzed.

You have heard much about the research idea. Dr. Howe has told you how it has progressed. No doubt Professor Adams and others emphasized last night and will emphasize again today what must already be very well recognized by all of you, that the spirit of research is rife. As a matter of fact, the pendulum is swinging so far that we wonder somtimes whether it has not gone beyond its equilibrium point. Sometimes I think that much that is done under the name of research is misnamed, and that much of it is really wasted effort. Not that any of us for a moment would question the value—the permanent, fundamental underlying value of real research work. It is necessary, however, to distinguish between genuine and spurious research—to encourage the one and prevent the other so far as possible.

The thought that I want to present to you of the field of research in in industry really comes out of what might be considered an academic picture of the research field. You may not agree with all of the distinctions which I have made in the chart. I am going to try to get you to believe the fundamental ones, or at least to present them to you in such a way that I can get some reaction that will change my own views. I want to start by distinguishing between scientific research and engineering. What is research, to begin with? Knowledge comes to us at times by chance, in a haphazard, fortuitous fashion, but only that is worthy of the name of research which comes as a result of diligent continuous seeking—of searching after facts and principles. The goal of research is truth. That, I think, is fundamental, whether the end in view is knowledge for knowledge's sake, or whether it is knowledge as a basis for application. Research is the way and means of getting at truth. It is scientific.

The distinction between scientific research and engineering is twofold in character. In the first place they are different because one consists in the acquisition of knowledge and the other in the application of knowledge; and in the second place they require a different training. Engineering is an art, and those who apply engineering are artists, or artisans, or any other term that you may use for those who are workers in an art. The training of an engineer is not the training of a research man, though there may be research men among engineers who are endowed peculiarly with the spirit of

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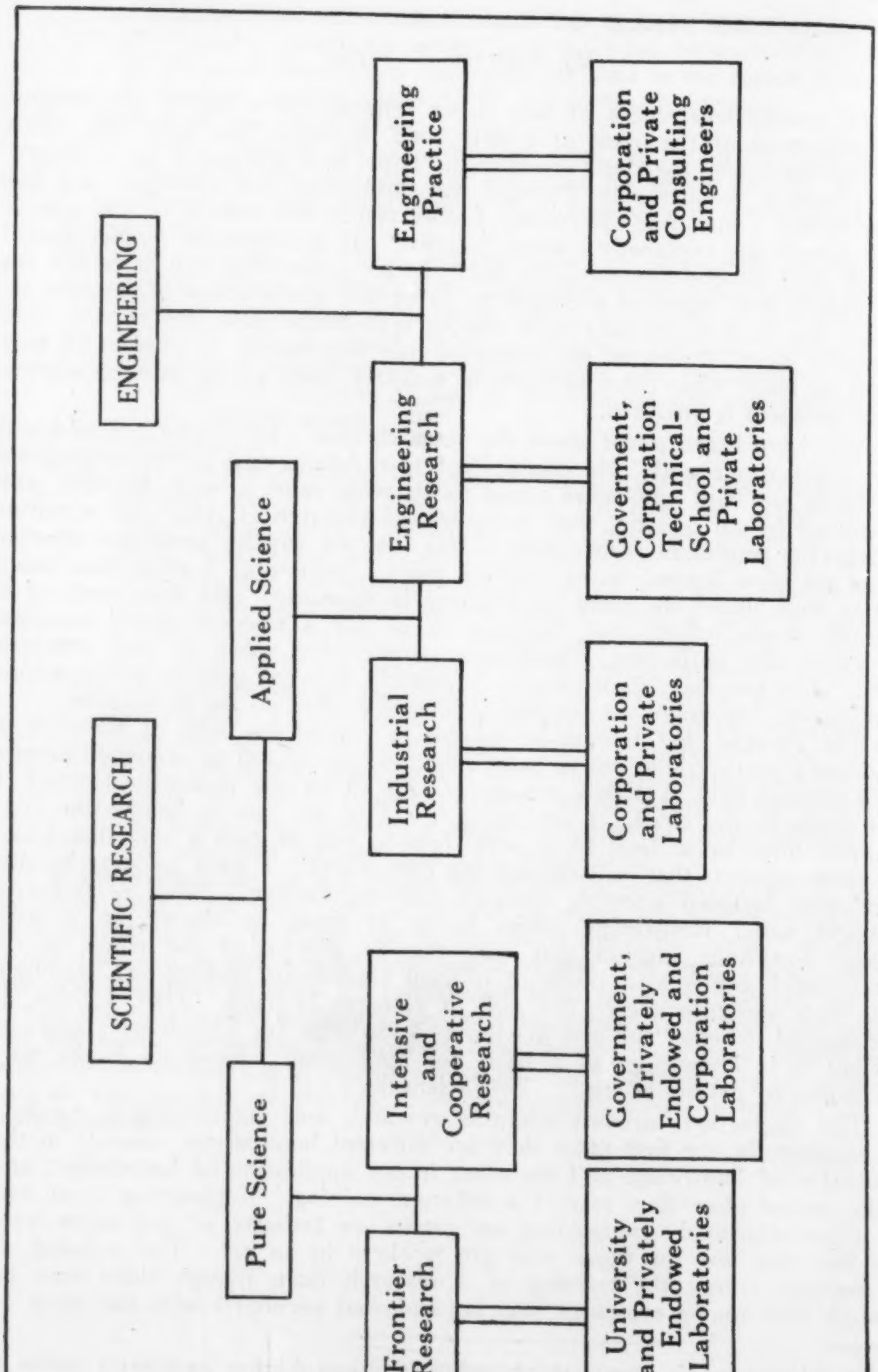
Revised stenographic notes of an informal paper presented before the research session of the Indianapolis Convention. The author, Dr. Edward P. Hyde, is director of research, Nela Research Laboratory, National Lamp Works of General Electric Co., Nela Park, Cleveland. The discussion of this paper will be found on page 98 of the November issue of TRANSACTIONS.



A CHART WHICH SHOWS THE PLACE RESEARCH ASSUMES IN INDUSTRY

seeking after knowledge, or who have come under the inspiration of some teacher whose approach is of that character; but, speaking in general terms, the training of an engineer is the training of an artist or an artisan.

Let us go a step further and make the distinction under scientific research between pure science and applied science. Many think we ought not to make any distinction here. The pure scientists are likely to make the distinction of "pure" and "impure" science, and applied scientists retort by saying it is "aplied" and "misapplied" science. But there is a distinction. When one is carrying out research work, searching after truth, he is constantly coming to branch points. One branch may lead in a direction that would seem to offer the largest field for the acquisition of knowledge. It may be the most practical in the long run. It may yield the largest returns in the long run, but the other one may lead in a direction which would seem to bring the investigator more quickly to something that is of practical value, that has a commercial, a monetary significance. That difference, as I see it, between the pure scientist and the applied scientist is not one of method or training, it is one of goal. When he comes to the branch point, the pure scientist will always follow the branch that gives promise of leading to the largest returns in knowledge, the other will take the branch that gives promise of the quickest and largest commercial return.

Let us go a step further and separate pure science into what may be called frontier research, on the one hand, and intensive and co-operative research on the other. To use a figure of speech, the geographical explorer is searching for uncharted lands. He has nothing to go on but his imagination. He is scouting around on the frontier. But after he has discovered some new territory, there must come behind him a corps of men who will canvass the mineral, the vegetable and the other resources of the new territory. They are the intensive workers, they are cultivating in an intensive way the new territory which he has opened up. Consider the work of a specific laboratory, such as the Geophysical laboratory in Washington where problems of geophysics are studied intensively. Another illustration, if I may mention it, is the Nela Research Laboratory of Pure Science where the physiologist, the physicist, the chemist, the biologist and the engineer are investigating questions that have to do with lighting; it is intensive work.

The two cases cited illustrate also what I mean by co-operative research. It is not the place here to develop this idea at length, but the importance of co-operation in intensive research merits a word in passing. Much knowledge is to be found in the no man's land between the various sciences, and conspicuous progress is certain to follow intensive research in this field.

Let us now consider applied science. Under that head I have put industrial research and engineering research. I don't know just how to make the distinction clearly, but there are certain fields of work which seem to come within the scope of engineering, and in these fields there is need for research. For example, the man who undertakes the investigation of the insulation problem, which is a very live subject at the present time, has a problem and a subject matter which is of interest to engineers.

With the above as a general classification, where should these various kinds of research work be done? I would suggest that frontier research be done by universities and by privately endowed laboratories. The university man is always bringing work up to the frontier of knowledge. He has a better idea of the whole frontier, and therefore he is the man to

whom we would most likely look to push that frontier just a little further, applying imagination to the accumulated knowledge. Privately endowed laboratories may accomplish similar results, and I am thinking, as an example, of the work of the Rockefeller Institution for Medical Research. There may be fundamental work done in a laboratory of that type which would come under the category of frontier research.

For intensive and co-operative research, I have put down government, privately endowed, and corporation laboratories. Here is where the government can very well step in. Many of us would not feel that it was the function of the government, that is, of the public to support men who are browsing around for extending the margin of knowledge. Personally, I would not object to having the government undertake such work, but I believe that the men in the universities are peculiarly fitted for it. The government, however, should take a large part in the intensive co-operative research. The work of the bureau of Standards, that is, the research work that it does, fits right in here. And so it is with a large number of bureaus of the government, and properly so.

Privately endowed institutions such as the Rockefeller Institution and Carnegie Institute, are peculiarly equipped to carry on work of this kind. The university man must teach, he must read, he hasn't the time nor the inclination to keep intensively working in some special field all the time. He hasn't the equipment. His views are changing from year to year. For that work we need a corps of men that is going to stay right there on the job, work at it morning, noon and night, with their equipment permanently set up. Nine-tenths of the time is spent in getting ready; the actual observations take but a little time. After a man gets an elaborate equipment set up, he is ready usually to go ahead and investigate a great many aspects of a subject. They are constantly suggested to him. As a matter of fact, the difficulty is that we become ingrown working this way. But this very condition of continued work with the same corps of men, saturated with the idea, is the underlying one in accomplishing results in intensive research.

Intensive research in pure science should be undertaken by the government and by privately endowed laboratories, but, in my judgment it should also be prosecuted in industrial laboratories. Some 13 years ago when we organized a laboratory for pure science in the National Electric Lamp association, now the National Lamp Works of General Electric Co., it was, so far as I know, the first of the kind to be organized anywhere in the world. Most of the industrial laboratories had been admittedly applied science laboratories, but apart from any question of repaying by industry an old debt to science—an adequate reason in itself—the assumption by an industrial corporation of intensive research in pure science should also be profitable. Industrial research is ordinarily conducted in a way to give quick returns. Intensive pure science research in the field in which an industry is interested will yield a deferred return on the investment. The return must come—it is only a question of time.

Under industrial research I have suggested that it should be carried out by corporation and private laboratories. It is now an admitted function of a corporation to have an industrial research laboratory. It hasn't always been so. Germany largely has pointed us the way to that idea, and although there were some industrial laboratories—and quite a number of them—before the war, that idea has gone ahead both in this country and throughout the world with tremendous impetus since the war.

I have added private laboratories as places where industrial research should

be done, for I think that the time has come when we must have in this country industrial research laboratories of a private character. I mean privately owned laboratories to undertake research for those industrial companies which do not have their own individual laboratories. I think there should be a large field for laboratories of that kind, because it is not every company that can afford the investment and the expense of a laboratory to investigate the problems that should be investigated in that industry. It requires a large investment and it requires a large annual expense because competent men are required, and a sufficient number of them to produce a well-rounded organization.

Under engineering research I have put down government, corporation, technical school and private laboratories. They are the places where, in my judgment, we might look for that kind of research which I described a while ago as engineering research.

From these general considerations, the author has come to the conclusion that the field of research in industry embraces intensive co-operative research in pure science as well as research in applied science, and that this latter applies not only to what has been called industrial research but also to what has been called engineering research.

AN ELECTRICALLY HEATED FORGING AND HEAT TREATING FURNACE

By G. M. Little

TO GIVE a brief account of the development of a resistance type electric forging furnace, some of the problems encountered, and how they were handled is the purpose of this article.

Reasons for Development. In practically all steel manufacturing centers it is not now possible to obtain a sufficient supply of natural gas to operate continuously the various furnaces used for forging, heat treating and melting. This is most often taken care of by substituting oil during those periods of absence and shortage of gas, but this is inconvenient and expensive. The ordinary forging furnace is not adapted for producer gas, the use of which demands an expensive regenerative heating system.

Advantages of an Electric Resistance Furnace. While the lack of natural gas is an important argument for an electrically heated furnace, it is also true that higher temperatures, than can be obtained by the use of gas or oil are desirable and are easily reached in an electric furnace. An electric furnace is a much more agreeable apparatus to work with. It is quiet, does not radiate much heat, does not require frequent or extensive repairs and is capable of turning out more work than the gas-fired furnace having the same work opening.

State of the Art. When this development started no electric forging furnaces were on the market. It is true some attempts had been made to meet the severe requirements. One scheme tried was a forging furnace in which a molten salt served as the heating resistor element. The current was passed through the salt, melting it, after which the iron bars were dipped into the molten bath and soon reached a forging temperature.

Another effort was a scheme whereby the ends of the bars to be heated were dipped into water rendered conductive by the addition of certain salts. A powerful direct current of electricity was sent through the water into the bar, thus causing the water to be decomposed and a layer of white hot hydrogen gas to form on the surface of the bar underneath the water. This quickly brought the bar up to forging heat.

A great many electric arc furnaces were being used for various purposes but apparently none for forging. The low power factor, difficult regulation, and rapid consumption of the electrodes probably prevented this development. An adaptation of the induction type of electric furnace had been used for rivet heating but nothing that could be called a furnace had been evolved.

There were many carbon plate and granular carbon resistor furnaces, more particularly for heating crucibles, which gave excellent service provided that the chamber in which the resistor was located was tightly closed to prevent oxidation. In practically all of these, the furnace could not be worked or forced hard so as to heat metal quickly, as the heating element lay against the refractory walls of the chamber, and these walls were quickly destroyed.

Present Design. A consideration of this latter type of furnace resulted in efforts which have overcome the main defects so that it is no longer

A paper presented at the Indianapolis Convention. The author, G. M. Little, is in the research laboratory, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

necessary to keep the chamber closed, and the carbon plate resistor will last some months with the working opening or door wide open all the time. This is accomplished by maintaining a reducing atmosphere or gas or oil vapor around the heating element.

Also, by the simple expedient of suspending the carbon resistor across the middle of the furnace chamber and away from the walls, the furnace can be forced considerably without damage to the walls. A further precaution was adopted in the selection of 4 x 4-inch carbon bars for the inside lining of the upper part of the furnace chamber. These bars will stand just as high a temperature as the heating element and will last a year in service, being protected from oxidation on the lower side by the same reducing atmosphere that surrounds the heating element, and on the upper side by a layer of carbon dust, which is slowly consumed, and has to be replaced at long intervals.

General Description. The furnace in its final form consists of a cast iron box about 4 feet long x 3 feet deep and 4 feet high, mounted on cast iron legs about 30 inches high. In the front side of the box is the familiar long narrow opening into which the iron bars are introduced, just as in the standard gas or oil-fired furnaces. At the sides are located water cooled bronze terminals and the copper leads by which the current is brought to the furnace.

The inside of the box is lined heavily with refractories and heat insulation, leaving space only for a chamber 30 inches long, 9 inches deep and 20 inches high. Reaching full length across the upper part of this chamber, but nowhere approaching the walls nearer than 3 inches is suspended the heating element. A small stream of natural gas is fed up through an opening in the floor into the furnace chamber continuously. This causes a small flame and some smoke to escape lazily from the upper edge of the opening, and a chimney connection has been provided in case this should be in any way objectionable.

Provision has been made in the back of the furnace to allow the brick work to be removed so that repairs to the heating element can be made readily. Wind shields are placed at the sides of the working opening which in some degree prevent the action of air draughts in the room, which tend to blow the protecting gas out of the chamber. The furnace takes from 16 to 40 kilowatts depending upon the size of the iron bars being heated and requires little regulation, hand control being found satisfactory.

Selection of the Heating Element Material. It is absolutely essential in a forging or melting furnace to be able to crowd or push it so that a large amount of metal can be brought to the desired temperature quickly. It was obvious then that any heating element would have to fulfill the following conditions:

(1) It must have a large radiating surface in order to radiate a large quantity of heat. (The filament of a tungsten lamp operates at a very high temperature, but does not radiate much heat).

(2) It must be strong at all temperatures as it may be subjected to shocks and jars from nearby steam hammers in the forge shop.

(3) It must not be injured by being operated at very high temperatures —probably up to and over 3000 degrees Cent.

(4) It must have a reasonably long life.

(5) It must be renewed easily.

(6) It must not be expensive.

(7) Its change in resistance due to change in temperature must not be very great.

Resistor Materials Other Than Carbon. A consideration of the above conditions and a survey of some of the materials which might be used resulted decisively in eliminating all except carbon.

(1) The rare earths such as are used in the Nernst lamp are expensive, are frail, and are insulators when cold.

(2) Nichrome will melt at the high temperature demanded.

(3) Tungsten is expensive and might melt or oxidize.

(4) Metallic oxides and sulphides will be melted or decomposed.

(5) Carborundum looked hopeful but it was found that great difficulty was encountered in starting the furnace cold, that no two resistors

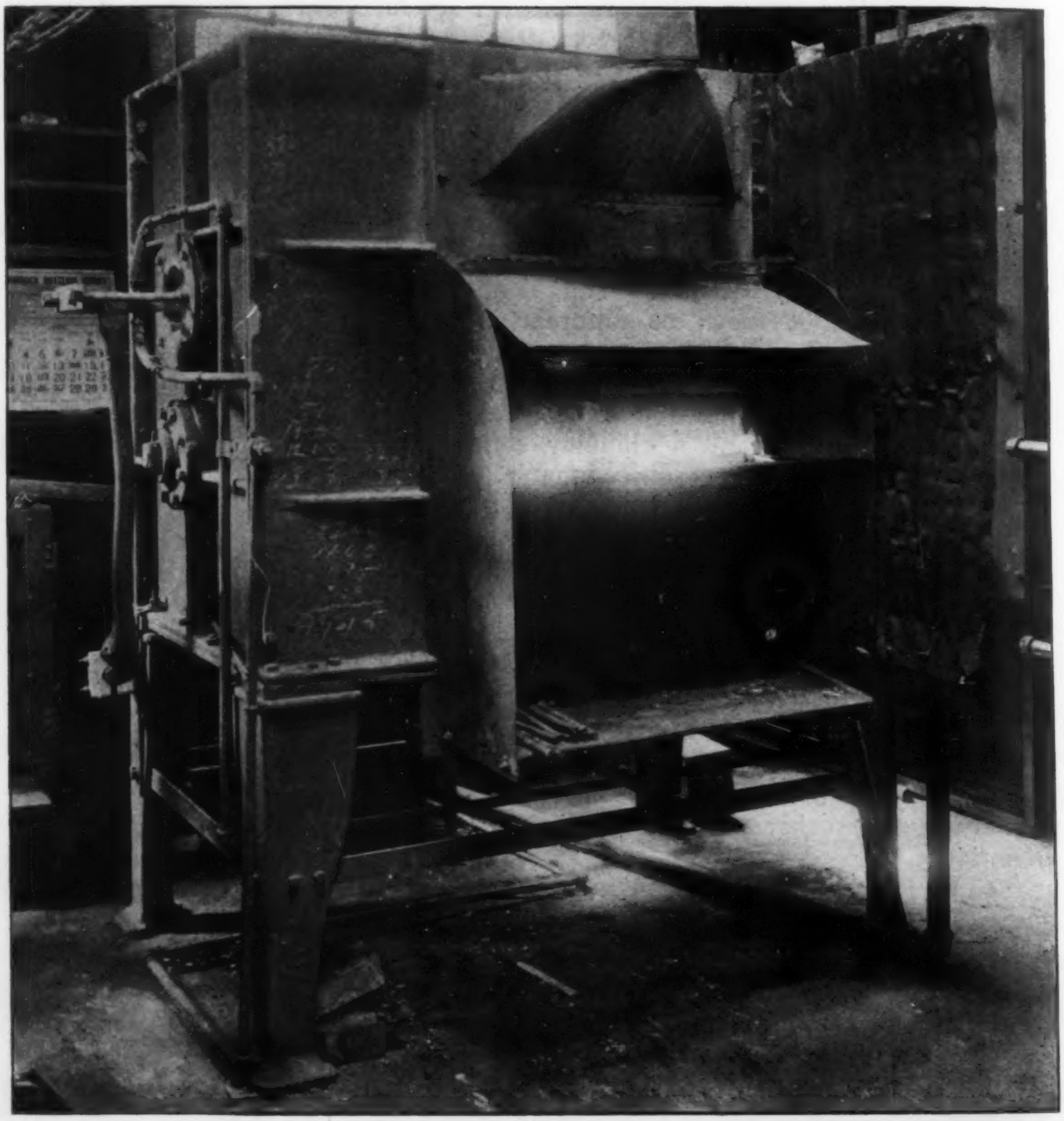


FIG. 1—FRONT VIEW OF RESISTANCE TYPE ELECTRIC FORGING AND HEAT TREATING FURNACE

were alike, and that they were apt to crack in two and start arcs which would destroy them. Carborundum decomposes at 2250 degrees Cent.

Carbon in some form appeared to be the only possible substance to consider. Graphite crucible material, which contains a large per cent of carbon and of kaolin was tried unsuccessfully. Granular carbon as ordinarily used would not do as it requires a supporting wall or trough of insulating refractory material and if the furnace were pushed, the supporting refractory wall or trough would be destroyed. It also has a most variable resistance in service. A carbon rod of practical size and strength used as a resistor would have such a low resistance as to require the use of an excessive current, necessitating very large copper leads.

A satisfactory result was obtained by the adoption of a heating element composed of a pile of carbon plates held together by a strong spring pressure which was applied to the ends of the pile. This complete heating element would handle over 100 kilowatts safely and cost only a nominal sum. About the only serious defect this carbon plate resistor had, was that it would be rapidly consumed if any air or water vapor came in contact with it while it was red hot.

Mechanical Means for Protecting the Carbon Plates from Oxidation. The most obvious remedy was to coat the surface of the resistor with some refractory glaze, however, there was no glaze that would stand the temperature. Burying the resistor in coke dust was effective against oxidation but was not suitable in other ways. Of course, the carbon heating element would last indefinitely in a vacuum, but this condition was impossible.

Protection by Means of Gases. The use of a surrounding atmosphere of inert gas, looked promising and a mixture of nitrogen and carbon monoxide, obtained by passing air through red hot carbon, was tried. This did protect the resistor considerably but did not give as satisfactory a result as was obtained by the use of hydrocarbon vapors, natural gas or oil, which not only prevented the action of oxygen on the resistor, but actually built on a little film of carbon just as is done in the "flashing" process in the manufacture of carbon incandescent lamp filaments. In this process thin spots in the white hot filaments are thickened by an accretion of carbon from the surrounding gasoline vapors.

Materials for Producing the Protecting Vapors. The hydrocarbon vapors may be introduced into or produced in the furnace chamber in several ways. Gas is easiest to handle and is, of course, ready to start its protecting action immediately. Oil has been used satisfactorily and other materials such as powdered coal or sawdust, if fed into the hot furnace, will give off their protecting vapors which will rise into the upper part of the chamber. It has been found that by this means the carbon heating element and carbon roof can be made to last for long periods, the resistor for several months and the roof for a year.

Means of Introducing the Hydrocarbon Vapors. The first experiments were made with natural gas which was introduced through a 1-inch carbon pipe projecting through the roof of the furnace. It was found that the pipe would soon choke up constituting an occasion for a difficult repair. A simpler and all round better scheme was to introduce the gas at the working opening or through the furnace floor where the pipe was at all times under observation and could be cleaned easily and quickly when necessary.

Gas Does Not Necessarily Fill the Entire Chamber. In the present design of furnace the working opening is near the bottom of the furnace chamber and any excess of gas escapes at the level of the top of this open-

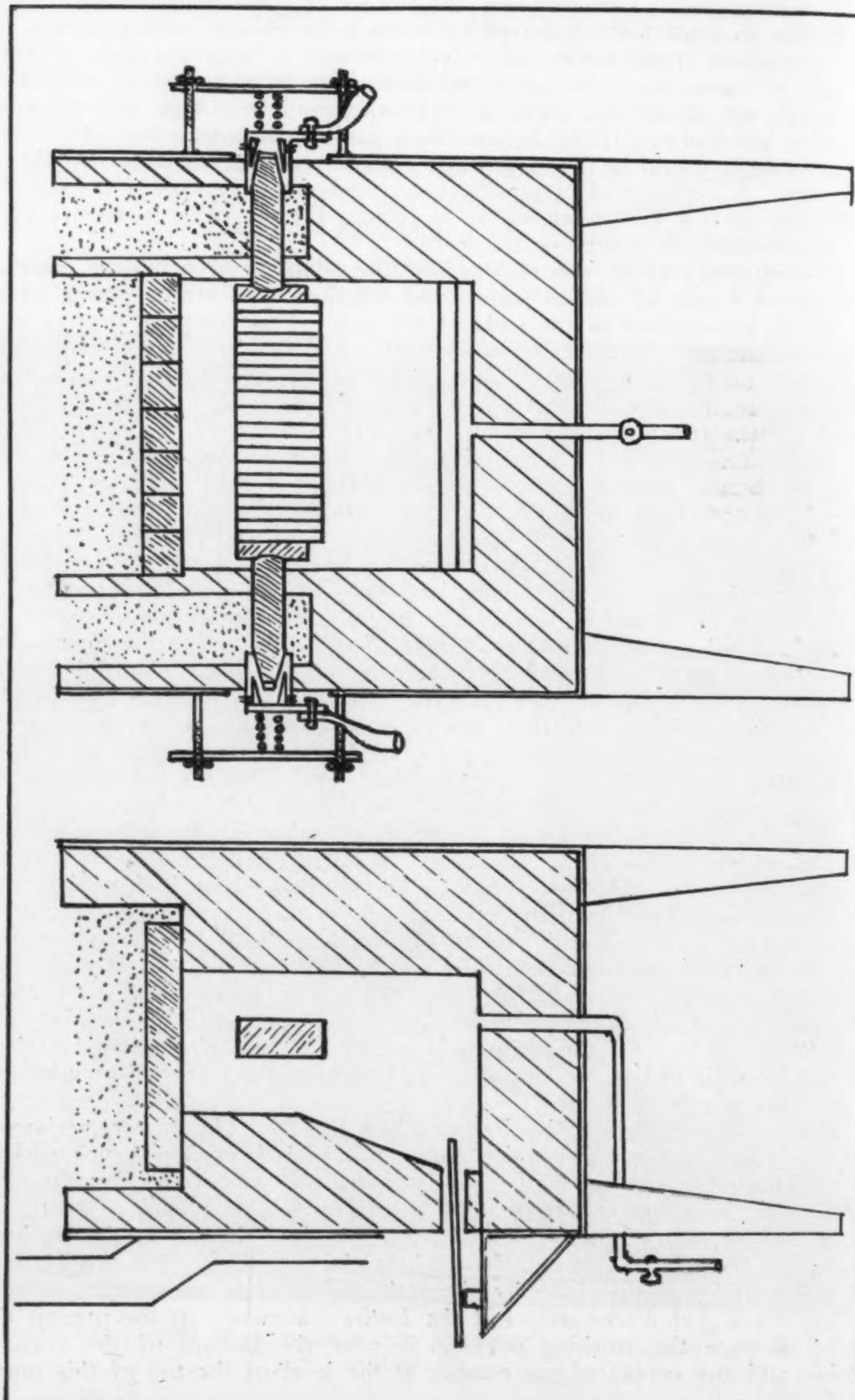


FIG. 2—TRANSVERSE AND LONGITUDINAL SECTIONS OF ELECTRIC FORGING AND HEAT TREATING FURNACE

ing—below that level the atmosphere in the furnace chamber is oxidizing. If, for any cause the supply of gas is shut off or is insufficient, it takes only about 100 cubic feet per day, the heating element is attacked by the inleaking air, most rapidly at the bottom and soon is consumed.

Oil. While it is advisable to use gas, when it can be obtained, to maintain the necessary reducing atmosphere in the upper part of the furnace chamber, it might sometime be necessary to use oil, and a variety of means of feeding it to the furnace were tried. The most successful scheme was to squirt the oil intermittently, a few drops at a time, from a fine jet mounted about 1 foot away from the working opening. The motor-driven pump had a 1/4-inch diameter piston and ⅛-inch stroke. This piston was raised slowly against a powerful spring pressure by means of a cam, at the top of its movement the cam released its hold and the springs vigorously forced the piston down, causing a few drops of oil to be thrown violently well into the furnace chamber. It was necessary to use about 1 gallon of oil in 24 hours. Heavy oils worked best.

Means of Obtaining a Relatively High Resistance in the Heating Element. Having decided upon the use of carbon plates, the size and thickness of the individual plates as well as the overall dimension of the assembled heating element were considered, and for a tryout, plates 6 inches long, 2½ inches wide and 1/4 inch thick were made up into two piles, each 15 inches long. These were clamped in the furnace chamber in series and held under about 200 pounds pressure. Natural gas was run into the chamber and the current turned on, about 50 kilowatts being used.

This first tryout was very successful. The furnace was kept up to a forging temperature for nearly six weeks. One undesirable feature brought out was the fact that on account of the low resistance of the heating element, a large current, 2000 to 2400 amperes was required to produce the necessary heating effect.

It was evident that the resistance could be increased a number of ways: (1) Thinner plates and more of them would give an increased number of resisting contacts in series; (2) have plates formed with projecting contact areas, which areas could be made as small as desirable; (3) make pile of plates of alternate full sized plates and small plates; (4) make the pile of plates of alternate full sized plates and granular carbon; (5) use a longer pile of plates; (6) use plates of smaller area; (7) have plates made from a form of carbon having a specifically higher resistance. All of these have been tried and all in some degree accomplished the desired change, though so far the best results have been obtained by using alternate full sized plates and small plates. By this means the current normally required has been reduced to about 1000 or 1200 amperes.

Renewal of the Heating Element. Two means of entering the furnace chamber are provided, through the top and through the back. If the furnace be allowed to cool down for 48 hours it is a simple matter requiring about two hours time to remove the top heat insulation and refractory lining, put in a new heating element, and put back the heat insulation and refractory lining. This is the method that has been used up to the present. It is probable that the renewal could be accomplished without waiting for the furnace to cool, by opening the back wall, holding a new heating element supported on a tray between the ends of the graphite electrodes, then tightening the springs and replacing the brick work. A removable section has been provided in the iron work to permit this to be done.

Furnace Lining. In this furnace, it is necessary that the heating element

be located in the upper part of the chamber where it is well protected by the blanket of gas from any inleaking air. From this it follows that the upper part of the chamber is by all means the hottest part of the furnace and for that reason it has been found advisable not to use in this zone the ordinary refractories such as fire brick, beauxite or magnesite, but to use for a lining, heavy carbon bars laid close together and covered with carbon dust. These carbon bars can not be melted and if protected from oxidation by means of the blanket of gas in the furnace chamber will last a year. The upper side walls are lined with carborundum brick which stand severe punishment quite well, so long as they do not have to carry current. The lower parts of the chamber where the temperature is kept down somewhat by the continuous introduction of iron bars, etc., may be lined with fire-brick. All these furnace linings will last much longer than do linings of gas-fired furnaces, owing to the absence of the cutting action of the blast.

Terminal Connection. Some unexpected trouble was experienced in that the 3-inch round graphite electrodes which serve to carry the current through the walls would burn in two in the middle of the wall. This has been prevented by making the wall hollow, where the graphite electrodes pass through, and filling in the space around the electrodes with coke dust.

Satisfactory contacts between the heating element and the graphite electrodes are accomplished by rounding the end of the electrodes which project into the furnace chamber, and providing hollowed out sockets in the graphite blocks which form the end plates of the heating element. This constitutes a ball and socket joint which allows a little movement should the shrinkage of the walls or heating element demand it. The water-cooled external connections are designed so as to permit several inches forward movement of the graphite electrodes to allow for shrinkage of the heating element. They are also fitted with a powerful spring and screw adjustment to keep the plates under heavy pressure. The water-cooled connections give no trouble and do not absorb much energy.

Heat Insulation. In any electric furnace, heat insulation is of vital importance. In this furnace, it has been found advisable to back up the inner refractory lining of carborundum, or fire brick with a layer of fire brick and then with two outer layers of high grade insulating brick next to the iron shell. The heat insulation on top consists of a layer about 6 or 8 inches deep of coke dust on which rests one or two layers of high grade insulating brick. The result of this design is that the radiation loss is small.

Control. The control of the furnace is exceedingly simple. The current is 25 cycle, single phase and is drawn from a 37-kilowatt transformer having six taps, making available voltages from 60 down to 20. When a new heating element is put in service, it has a high resistance and a start is made on the 60-volt tap. As the furnace heats up the resistance becomes lower, partly because of the negative temperature coefficient of carbon and partly because a thin dense layer of carbon deposits from the gas on the outside of the heating element. The plates also become fitted together much more perfectly under the influence of the high temperature and high pressure. This lowering of the resistance, which is unavoidable, is compensated for by changing the transformer connection to one of the lower voltage taps. After the first two days, the changes in resistance take place slowly and if the work is fairly steady, the furnace will run for days at a time on a single tap.

Several schemes for automatic temperature control have been worked upon but it has not been found necessary for forging operations to use

anything but hand control. A furnace was operated continuously heading bolts for five months this way. As an illustration of the ease of operation, it may be said that through the day this furnace was operated with the writers' knowledge and care, but through a misunderstanding, it was also operated each night without his knowledge and with no special directions having been given the workman who experienced no trouble. One of the desirable features of this furnace is the high power factor which is probably in the neighborhood of 95 per cent.

Cost of Operation. The greatest expense is of course the cost of the current, which varies considerably in price in different locations. With this information furnished, the cost of operation may be readily figured since the furnace requires from 16 to 22 kilowatts for medium sized and small iron bars and perhaps up to 40 kilowatts for larger work. As a rule, the cost of current is less at night so that even though the furnace is not used at night it may yet be desirable to keep a little current flowing, but if this is not

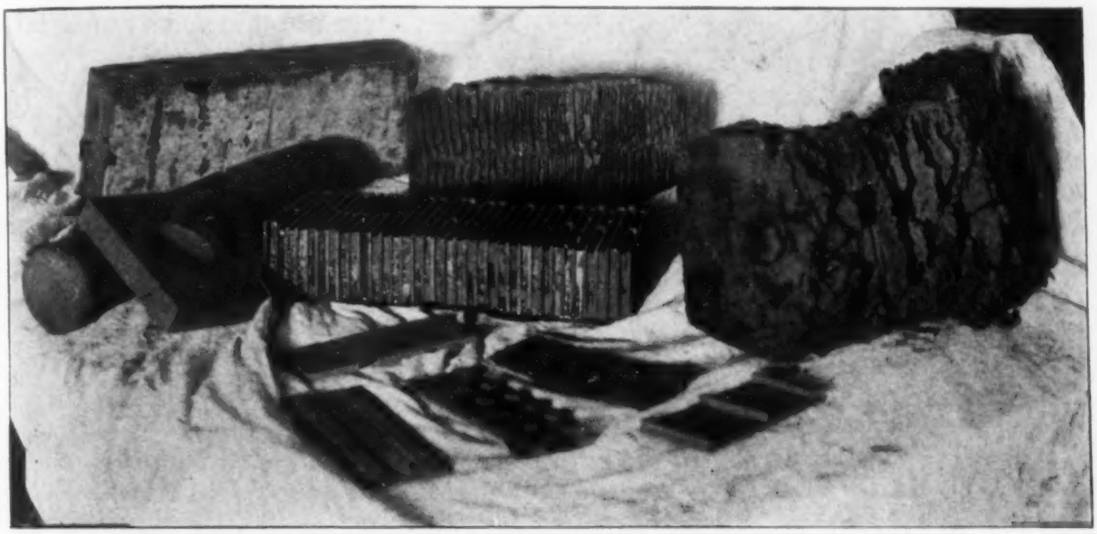


FIG. 3—CARBON ELECTRODES AND TERMINAL CONNECTORS USED IN THE FURNACE

done, the furnace may still be brought up to heat rapidly in the morning by crowding it for an hour or so.

The renewal of the heating element is expected to occur not oftener than once in three months at a nominal cost for materials and two hours time. The refractory lining is expected to last in the neighborhood of a year. It is expected that the upkeep and repairs will be much less than with gas-fired furnaces. One item which tends to reduce the cost of operation per pound of metal heated, is the fact that the furnace may be run at a higher temperature than the gas-fired furnaces and the bars of iron can be rushed through faster.

Future Development. The work in the past has been mostly directed toward producing a forging furnace, but a muffle-type calcining furnace has been started and a small experimental brass melting furnace using a carbon plate heating element was built This brass melting furnace gave some interesting results. It was seen that with 50 kilowatts it was a simple matter starting with cold pigs, to melt and pour 100 pounds of brass in 15 minutes.

The bath of metal could be subjected to either oxidizing or reducing conditions at will. The zinc loss was very small.

There was not the tendency to intense local heating ordinarily found in arc furnaces. No trouble was encountered in shutting down and starting the furnace cold. The entire charge could be poured at each heat. It was also found that steel could be melted readily in this furnace without damaging the heating element or other parts.

CARBURIZING HEAVY SECTIONS

By W. I. McInerney

AS MOST of the papers on carburizing presented before meetings of the society have dealt with surface carburizing, a short paper on some of the methods and results obtained in deeper carburizing, that is, in a measurable increase in the carbon content of the section from the surface to a depth of 2 inches should be of interest. The process of carburizing, or as it is sometimes called carbonizing or cementing though the term carburizing is the generally accepted term as applied to heavy sections, is probably more extensively used in the manufacture of armor plate than any other branch of the steel industry.

Modern practice requires a carburization for a depth of one inch or more, and to get the proper graduation from the surface to the required depth, and not get excessive concentration in the surface strata is the problem that confronts the heat treater, and the carburizing compound manufacturer.

The theory of carburization which is usually brought forth as an introduction to such a paper as this, is familiar to all, as are also the different tables on the acceleration and retardation of the different elements and the percentages of times necessary to add or subtract when using steels of different compositions. For the purposes of this paper the compositions of the steel was practically the same in all cases except as noted.

Of the three carburizing agents, namely liquid, solids or gaseous, the solids have been more extensively used than either of the other two. There are certain requirements that must be met by the carburizing agent before it will prove satisfactory for use in this particular line, a few of which are:

1. Uniformity as to composition and physical qualities, grain or pellet size.

2. Freedom from sulphur in injurious amounts less than 0.5 per cent.

3. Freedom from internal combustion.

4. It should not flux or fuse at any temperature up to 2100 degrees Fahr.

5. It should not coke or cake on the plate making it difficult to remove.

6. It should also have a good bearing value and minimum shrinkage so as not to crush excessively in use.

Home made carburizers have not proven any more economical than the commercial ones, and are not as satisfactory due to the difficulty in properly mixing them and the liability of infringing on already patented compounds.

The practice from which the accompanying results were obtained differs considerably from the usual run of carburizing in that no pots, boxes or other containers are used. A plate to be carburized is forged

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to thickness somewhat in excess of the final thickness, then after proper heat treatment which usually consists of annealing to prevent cracking in the subsequent cooling after forging and the reheating to carburize, it is prepared for carburization. After removing all surface scale, any seams or tears are chipped out so that when the final forging is completed after carburizing a smooth even surface will be obtained and the necessity of machining eliminated.

Where a superficial depth of carburization is sufficient, that is to approximately a depth of ⅛ or 3/16-inch from the surface, the plate is first preheated to a temperature of 1500 degrees Fahr., taken out of the furnace and the carburizer spread on the hot plate for a depth of 2 inches or more and a layer of some refractory, usually dry yellow clay, sifted through a ¼-inch mesh, is put on top of this for a depth of 3 inches or more. The thickness of both layers depends on the depth of carburization desired. The plate is then recharged and the heating continued, temperature and time governing the depth and amount of carbon absorbed.

The carburizer used in this practice must be such that it will not burn up as soon as it is spread on the hot plate; it must not flux or stick to the plate when dumped off and should be uniformly active from the start to the finish of the run. In heavier sections where a greater depth of carburization is required, the plates are put together in pairs, sandwich fashion, that is the surface of one of the plates which is selected to be carburized has either a brick wall, one or two courses high, built around its edge or an angle iron frame is substituted. The purpose of either brick or angle frame is to form a recess or separation between the upper and lower plates which contains the carburizing material.

Usually when four such pairs of plates are prepared they are charged two pairs in tandem on a car-bottom furnace, the latest types of which have a car bottom 15 feet wide and 52 feet long, and are designed to carry a load of 600 tons. It is not unusual for an average load of eight plates to total 500 tons.

An experiment to determine the rate of carburization was made using 10 pieces 4 x 12 x 24 inches, one piece being withdrawn from the furnace every 24 hours, and the increase of carbon determined for each 1/16-inch from the surface with the following results:

Temperature 1870 degrees Fahr. Base carbon 0.28 per cent

		Per cent of carbon at various depths				
Piece No.	Hours	1/16 inch	¼inch	½ inch	1 inch	1½ inch
1	24	0.93	0.60	0.40	0.29	0.28
2	48	0.94	0.62	0.53	0.30	0.28
3	72	0.95	0.64	0.54	0.31	0.28
4	96	0.95	0.67	0.57	0.33	0.29
5	120	0.96	0.68	0.59	0.34	0.30
6	144	0.97	0.71	0.61	0.35	0.32
7	168	0.97	0.73	0.63	0.37	0.33
8	192	0.98	0.75	0.65	0.38	0.34
9	216	0.99	0.78	0.67	0.41	0.34
10	240	1.00	0.80	0.69	0.42	0.35

In the lighter sections up to 5 inches in thickness, a sufficient depth of carburization can be secured during the heating for final forging,

after preheating to 1500 degrees Fahr. and covering with the carburizer, heating is continued with the following average results:

Preheating previous to covering—12 hours
After covering to reach forging temperature—10 hours
Soaking at forging temperature—24 to 30 hours
Average base composition—Carbon 0.50, chromium 2.10, and nickel 3.50 per cent
Per cent of carbon at various depths

1/32 inch	1/16 inch	1/8 inch	1/4 inch
0.90	0.98	0.80	0.60

A comparative experiment using four different commercial carburizers between two sections 12 inches thick, gave the following results:

Average base composition—Carbon 0.32, chromium 2.36 and nickel 3.66 per cent
Temperature held at 1925 degrees Fahr.

	Per cent of carbon at various depths.			
Mixture No.	1/16 inch	1/8 inch	1/2 inch	1 inch
1	1.24	1.22	0.84	0.52
2	1.55	1.47	0.97	0.50
3	1.36	1.32	0.88	0.53
4	1.20	1.17	0.78	0.51

After further investigation mixture No. 1 was selected as the best for the purpose intended.

Another experiment with two commercial carburizers to determine the effect of prolonged holding at a temperature of 1970 degrees Fahr. gave the following results:

Average base composition—Carbon 0.48, chromium 2.35, and nickel 3.84 per cent
Time to reach temperature—100 hours or 4 days 4 hours
Time held at temperature—484 hours or 20 days 4 hours

	Per cent of carbon at various depths							
Material No.	1/16 inch	1/8 inch	1/4 inch	1/2 inch	3/4 inch	1 inch	1 1/4 inch	1 1/2 inch	2 inch
1	2.20	2.04	1.61	1.35	1.14	0.91	0.78	0.65	0.50
2	1.87	1.67	1.45	1.34	1.12	0.92	0.71	0.62	0.49

The practice of firing back before stripping after the completion of the carburizing treatment has not been put into regular use as whatever points that have been claimed for it are offset by the additional furnace time required. The usual practice on heavy sections is to strip the furnace after the required time has elapsed, the carburizer is dumped off and the heavy scale which forms on the exposed areas falls off and the face, or carburized surface, of the plate which has cooled in the meantime to about 1500 degrees Fahr., is covered with a protecting layer of buckwheat coal and a layer of dry yellow clay and heated for final forging.

THE FUTURE FUEL FOR THE HEAT TREATMENT OF STEEL

By H. O. Loebell

HEAT treatment of steel is essentially and primarily a heat operation and therefore the introduction and utilization of the most desirable fuel is a problem of prime importance to the industry. This article does not consider the physical, mechanical or metallurgical aspects of heat treatment, but deals with the introduction, utilization and application of a fuel which will permanently solve the heating problem.

Important fuels of today are fuel oil, pulverized coal and industrial manufactured gas. Fuel oil is a desirable fuel but because of insufficient supply we cannot consider it as a future fuel for our industry. Some years ago fuel oil was selling at 2½c per gallon and could be obtained in any desired quantity. Today fuel oil is selling from 12c to 15c per gallon and in many cases cannot be obtained at any price. Fuel oil consumers are now on the lookout for another fuel. This condition brings out the important fact of considering the permanency of a fuel. Millions of dollars will be spent on future furnace construction and installation and we must therefore consider a fuel which will be permanent and which will continue to serve the industry in the future. Powdered coal is desirable in many cases but this fuel is only an intermediate development in the final solution of the problem. Ultimately we realize that our enormous coal resources will be treated in such a fashion that we will obtain all the valuable materials from a ton of raw bituminous coal. We can obtain 20 million B.t.u. in a form most desirable for heating operations and also 20 gallons of fuel oil and 20 pounds of ammonia. Furthermore, the ash of pulverized coal is a destructive agent. The fusion of this ash in the furnace attacks the furnace lining to such an extent that it would be necessary to shut down and make repairs too often for satisfactory continuity of operation.

Today it is an established fact that the most flexible and efficient heating medium is a gaseous fuel. The bituminous coal resources are practically inexhaustible and they will therefore act as a raw material for the production of a fuel which will be permanent. From this coal we can make a gas which is efficient and desirable and at the same time obtain all the valuable by-products that are in the coal. Such a fuel besides being permanent will never be prohibitive as far as price is concerned as methods of gas production, distribution, and utilization are always becoming more efficient. Therefore, the price of a gaseous fuel would have a tendency to decrease.

The essential advantages of a gaseous fuel are well realized. In the first place it permits flexible furnace design, that is, from a consideration of the nature of the product, the furnace can be designed in any way that is deemed necessary and the fuel can be applied in any manner which the particular type of furnace demands. With the gaseous fuel ash is eliminated and no storage space is required. The gas is piped to the furnace and its application is only dependent upon the turn of a valve. With this fuel the most efficient combustion is obtained with the least amount of excess air. The control of furnace temperature is essential to good heat treatment and the temperature of a gas furnace is very easily

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controlled. At a large plant in Toledo, carbonizing furnaces heated with gas have a temperature control varying only 10 to 15 degrees.

Assuming that gas is the ideal industrial fuel the following questions may be asked. Will any kind of manufactured gas be suitable for steel heat treatment, and if not, which gas has the required physical and chemical properties to adapt itself to practically all heating operations? To realize the possibilities of an industrial gas requires a careful study of its physical and chemical properties, the most important of which are as follows:

1. Theoretical flame temperature.
2. Thermal value.
3. Chemical composition.
4. Rate of flame propagation.
5. Ignition temperature.

Table I

Properties of Important Industrial Fuels

Number	Kind of Gas	Constituents of Gas—Per Cent by Volume													
		CH_4	C_2H_6	C_2H_4	CO_2	CO	H_2	O_2	N_2	H_2O Vapor	B. T. U. per Cu. Ft. Gas 60 Degrees Fahr.	Cu. Ft. Air per Cu. Ft. Gas for Combustion	Products of Combustion per Cu. Ft. Gas	Theoretical Flame Temperature Degrees Fahr.	B. T. U. per Cu. Ft. Products of Combustion 60 Degrees Fahr.
1	Blue Water Gas	2.0	..	...	4.0	45.0	45.0	0.5	2.0	1.5	313	2.32	2.88	3595	108.5
2	Blue Water Gas	2.0	..	...	6.0	38.0	48.0	0.5	5.5	...	300	2.24	2.81	3580	107.0
3	Carbureted Water Gas...	25.0	..	8.5	3.0	19.0	40.0	0.5	4.0	...	563	5.06	5.77	3510	97.5
4	Manufactured Coal Gas....	40.0	..	4.0	0.5	6.0	46.0	0.5	1.5	1.5	626	5.64	6.37	3510	98.5
5	Coke Oven Gas	33.95	..	5.15	2.56	6.08	47.88	0.6	3.8	...	600	5.24	6.00	3555	100.0
6	Producer Gas, Hard Coal Using Steam.	...	..	...	5.0	25.0	20.0	0.5	49.5	...	146	1.08	1.86	3020	78.5
7	Producer Gas, Soft Coal....	3.0	..	0.5	5.0	23.0	10.0	0.5	58.0	...	145	1.13	1.98	2860	73.0
8	Producer Gas..	4.68	..	0.15	9.1	14.1	9.62	0.33	62.2	...	127	1.03	1.91	2570	66.5

The theoretical flame temperature of a gas is the maximum temperature that can be obtained. In practice this is never realized due to slow combustion, incomplete combustion, radiation and over-ventilation losses, and various minor conditions. The higher the gas flame temperature, the greater the differential temperature between the gas and the material in the furnace, which results in greater heat transfer and greater production per unit time. By thermal value of a gas is usually meant the B.t.u. content per cubic foot at 60 degrees Fahr. However, the thermal value that actually counts is the thermal value per cubic foot of burned gas, because the heating is done by the heat in the burned gas. The more heat per cubic foot of burned gas or products of combustion, the greater is the heat available for heating the material.

By varying the chemical composition of a gas, many of the factors of the efficient utilization of the fuel can be varied. For instance, if a gas contains appreciable amounts of hydrocarbons, it cannot be preheated before burning as the hydrocarbons would decompose and eventually

clog up the preheating apparatus. Then again, the rate of flame propagation and the ignition temperature depends on the chemical composition of the gas. A gas that contains small amounts of hydrogen requires a high ignition temperature and has a corresponding low rate of flame propagation. A gas of this kind burns slowly with a long flame and therefore requires a relatively large combustion area for the liberation of a given number of heat units. On the other hand, a gas with a high hydrogen content requires only a low temperature for ignition; the rate of combustion is very rapid, and relatively speaking, only a small combustion area is necessary for the liberation of a given number of heat units. Because of its high hydrogen content, blue water gas has the highest rate of flame propagation of any industrial gas. This is a decided advantage because a relatively large number of heat units can be liberated per unit volume of combustion space and thus a smaller combustion space is required than for other industrial gases. In Table I are shown the various properties of the most important industrial gases.

In judging the merit of an industrial gas by its B.t.u. value per cubic foot, it would be found that manufactured coal gas of a 626 B.t.u. value would be the best; blue water gas with a B.t.u. of 300 would be second, and producer gas would be third. These gases do not rank in this order, however. To judge correctly the merit of a gas by its heat content we must realize exactly what takes place during combustion. When a gas is burned, the heat developed is utilized immediately to heat the products of combustion or the burned gases. The burned gases give up their heat to the furnace walls and materials in the furnace. Thus the true source of the heat is the heat in a unit volume of the products of combustion. Also the flame temperature is directly proportional to the heat units in a cubic foot of the burned gases. The more B.t.u's supplied per cubic foot of products of combustion, the higher will be the flame temperature. This shows that not only are more heat units available but a greater temperature differential is secured between the flame and furnace material, and therefore causes a greater rate of heat transfer from the gas flame to the material in the furnace.

For the combustion of 1 cubic foot of coal gas of 626 B.t.u. value is required 5.64 cubic feet of air. The volume of the products of combustion is 6.37 cubic feet. From this is obtained the B.t.u. content per cubic foot of the products of combustion, which is 98.5 B.t.u.'s. By knowing the specific heats of the various gases in the products of combustion, the theoretical flame temperature is found to be 3510 degrees Fahr. With 1 cubic foot of blue water gas of a 300 B.t.u. value, 2.24 cubic feet of air is required for combustion. The volume of the products of combustion per cubic foot of gas burned is 2.81 cubic feet. From this it is found that the heat in 1 cubic foot of the products of combustion is 107 B.t.u., and the theoretical flame temperature is 3580 degrees Fahr. With a producer gas of a 145 B.t.u. value per square foot is required 1.13 cubic feet of air for combustion. The products of combustion for 1 cubic foot of gas burned amount to 1.98 cubic feet. Calculating as in the previous cases, it is found that the heat in 1 cubic foot of the products of combustion is only 73 B.t.u.'s and the flame temperature is 2860 degrees Fahr. From this chart, therefore, it is observed that blue water gas contains more B.t.u.'s per cubic foot of products of combustion and has a higher flame temperature than any other industrial gas. This shows that per cubic foot of burned gas, blue water gas has both more heat content and

greater heat intensity than any other industrial gas. This means greater heat transfer, greater production and higher efficiency.

Because the fuel and air are preheated to obtain a high working temperature and also to obtain a better thermal efficiency, let us consider the theoretical flame temperature of these different fuels using varying preheating temperatures for the air alone and for the air and gas. Curves of this data show that blue water gas has the highest flame temperature.

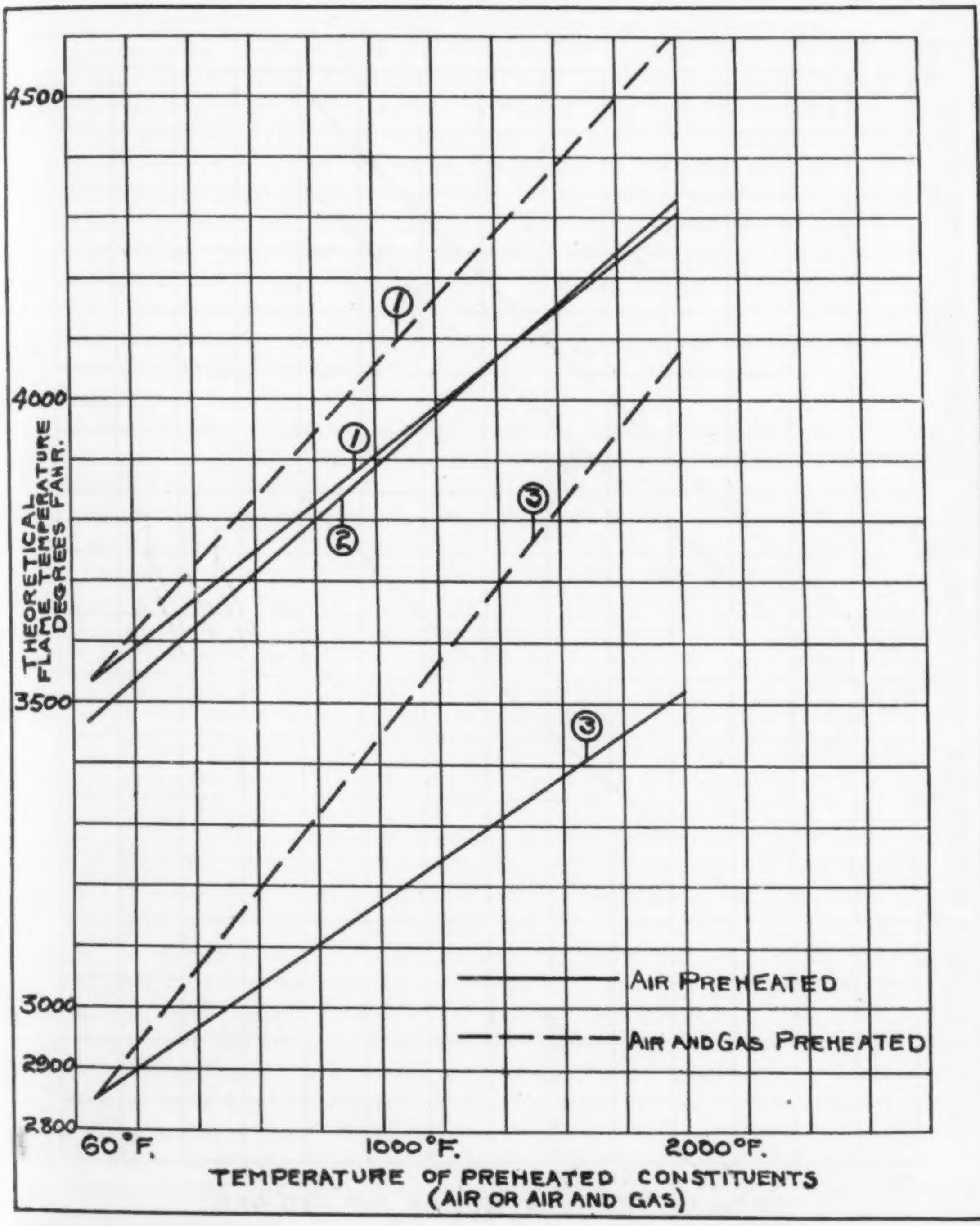


Fig. 1—Theoretical Flame Temperatures of Various Gases, Air Preheated and Air and Gas Preheated. Curve No. 1 is for Blue Water Gas of 300 B.t.u. No. 2 is for Carbureted Water Gas of 560 B.t.u. and Manufactured Coal Gas of 600 B.t.u. Manufactured Coal Gas Cannot Be Preheated. No. 3 is for Producer Gas of 145 B.t.u.

This fact is an important item in increasing the efficiency of the furnace and increasing production. As an illustration suppose we were to burn blue water gas and producer gas in identical furnaces, having the gas and air for combustion preheated to 1000 degrees Fahr. The theoretical flame temperature of the producer gas would be 3450 degrees Fahr., and if we had an operating furnace temperature of 2500 degrees Fahr., we would have a differential between the flame and the furnace of 1550

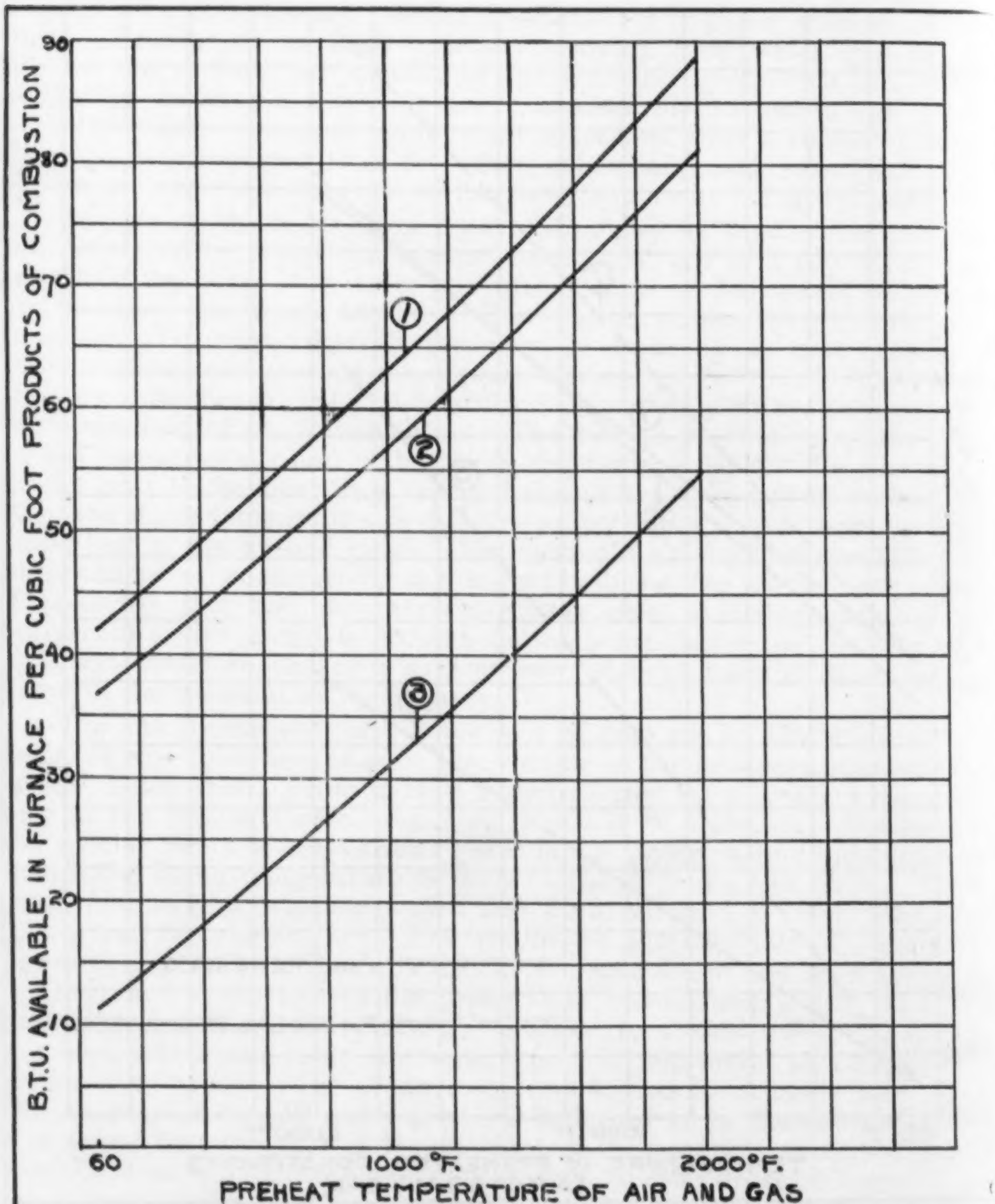


Fig. 2—B.t.u.'s Available in Furnace Per Cubic Foot Products of Combustion, Flue Gases Leaving Furnace at 2500 degrees Fahr. Curve No. 1 is for Blue Water Gas. No. 2 is for Manufactured Coal Gas. Since This Cannot Be Preheated, a Higher Preheat Temperature is Obtained on the Air. No. 3 is for Producer Gas

degrees Fahr. for blue water gas and 950 degrees Fahr. for producer gas. By having this greater differential using blue water gas greater production and better efficiency is obtained than by using producer gas under similar conditions.

In Fig. 1 is considered the gases from a flame intensity standpoint and in Fig. 2 is considered these industrial fuels from a heat content standpoint per cubic foot of products of combustion. In the latter case, blue water gas has the greatest heat content under any condition of preheated air and gas. Using blue water gas and producer gas in identical furnaces with the air and gas preheated to 1000 degrees Fahr. and flue gas leaving at 2500 degrees Fahr., 63 B.t.u. is available using blue water gas and only 31 B.t.u. using producer gas per cubic foot of products of combustion. In other words, under these conditions about twice as many B.t.u.'s per cubic foot of products of combustion is obtained using blue water gas than is the case when using producer gas. This means that at least twice as much work can be done with the furnace using blue water gas than with the furnace using producer gas per unit time, and since the heat losses per unit time are about the same for both furnaces, a much greater thermal efficiency is obtained on the furnace using blue water gas. From these curves it is seen that as far as chemical and physical characteristics are concerned, blue water gas is by far the better gas.

The fact that a large number of producer gas plants are in existence is no argument against the use of blue water gas or any gas made from coal where all by-products are recovered. The producer gas plant is a part of the industrial institution of the past and only cheap and abundant fuel is justification for its use. One advantage of a gas producer is that a wide range of fuels can be gasified. In fact, almost any kind of carbonaceous material can be converted into producer gas if it does not carry too much water or is not too greatly diluted with noncombustible material. The gas formed, however, may be difficult and uneconomical to use. Although producer gas is the cheapest gas which can be made per B.t.u. at the present time, yet its dilution with inert gas and its chemical characteristics greatly diminish its attractiveness as an industrial fuel.

. To substantiate our theory and to show the advantages of a gaseous fuel, particularly a gas with a high flame temperature such as blue water gas, the results of several installations made during the past few years will be given. In comparison with fuel oil the following results have been obtained. Under the best conditions of oil utilization it has been found that 5½ gallons of 142,000 B.t.u. oil can be replaced by 1000 cubic feet of a 600 B.t.u. manufactured gas. Under conditions where oil was used with lower efficiency 14 gallons of 142,000 B.t.u. per gallon oil has been replaced by 1000 cubic feet of 600 B.t.u. manufactured gas. In other words, from 800,000 to 2,000,000 B.t.u.'s using oil as a fuel has been substituted by 600,000 B.t.u.'s using a manufactured gas with a high flame temperature as a fuel. A pound of coke has been replaced by 14 cubic feet of coke oven gas or 8400 B.t.u.'s of high flame temperature gas by 14,400 B.t.u.'s in coke. In comparing two gaseous fuels, one with a high flame temperature and one with a low flame temperature, it was found that 59 B.t.u.'s of coke oven gas has been made to do the work of 100 B.t.u.'s of producer gas. At Buffalo in the heating of wrought iron 36,900 cubic feet of producer gas was replaced by 6800 cubic feet of coke oven gas or with 4,000,000 B.t.u., of high flame temperature gas,

the same work was done as with 5,400,000 B.t.u's of a relatively low flame temperature gas such as producer gas.

At a large automobile plant on high temperature forging we have substituted 11 B.t.u.'s using coke oven gas or 10 B.t.u.'s using blue water gas for 15 B.t.u.'s using fuel oil. From this example it is seen that the possible efficiency of utilization of a fuel is directly proportional to its flame temperature and this fact coupled with the actual comparative operating results prove conclusively that the most efficient fuel is one having a high flame temperature, such as blue water gas.

Another factor of essential importance in the heat treatment of steel is the formation of scale or the oxidation of the metal. Flue gases of any fuel contain varying amounts of water vapor, carbon dioxide, carbon monoxide, and nitrogen. When the fuel is burned with an excess of air the flue gases contain an appreciable amount of oxygen. This oxygen unites with the steel forming the undesirable oxide or scale. To reduce the scale effect to a minimum, it is good practice to burn the fuel with a slightly insufficient amount of air so that the flue gases contain a small percentage of carbon monoxide and no oxygen. Under these conditions far better results have been obtained with a high flame temperature gaseous fuel than with fuel oil. At one of the largest automobile plants in the country some 200 tests were run during a period of several weeks to determine the relative values of fuel oil and blue water gas for high temperature forging. The results were decidedly in favor of the gas. On several weeks actual production the following results were obtained:

1. Increased production for gas over oil, 24.6 per cent.
2. Fuel saving of gas over oil on basis of oil, 27.4 per cent.
3. The gas furnace showed 36.6 per cent less scaling effect than the oil furnace.
4. The oil furnace had 800 per cent more burned forgings than the gas furnace.
5. Rejections were 50 per cent more on oil furnace forgings than on gas.

Because of the fact that the gas supply and air supply is so easily controlled almost any desired atmosphere is maintained in the furnace. Blue water gas undergoes combustion more readily and more quickly than any other fuel and therefore only the effect of the flue gases on the steel need be considered. For fuels which require slow combustion not only must the effect of the flue gases on the metal be considered but also the various constituents of the unburned fuel together with the nitrogen-oxygen mixture of the air. With such a fuel which undergoes slow combustion, it is often necessary to have a separate combustion chamber so that by the time the products of combustion reach the metal of the furnace, the unburned fuel has been consumed entirely and no unburned fuel or oxygen is left to come in contact with the metal. Therefore, as far as our knowledge goes at the present time, a gaseous fuel of high flame temperature and of a high rate of combustion is best adapted to heating operations.

Practice has reached the point where a slightly under-ventilated flame is used and the flue gases contain water vapor, carbon dioxide, carbon monoxide and nitrogen thus only small amounts of scale are found. Today this represents the best and most efficient practice. As far as is known nitrogen is inert and does not effect the metal. Carbon monoxide after prolonged heating will tend to effect decarbonization but when it is

present only in a small percentage, its effect is not detrimental. Water vapor reacts with the steel forming magnetic oxide of iron and hydrogen. It has been found that at the high temperature, the steel is readily oxidized by carbon dioxide forming iron oxide and carbon monoxide. In passing pure carbon dioxide over the metal at 2000 degrees Fahr., it was found that the metal was readily oxidized to the extent of 14.5 per cent and the final analysis of the gas showed only 70 per cent carbon dioxide and 30 per cent carbon monoxide. These results show conclusively that the metal is not only oxidized by the water vapor but is also effected by the carbon dioxide content of the flue gases. This problem is one of interest and further research and experimentation probably will show relative effects of all constituents of the flue gases on the metal.

The manufacture of a gas such as blue water gas is extremely flexible. It can be manufactured so that it will have a high carbon content and low hydrogen content if it is found that such a gas is preferable. If it is found that a gas with a high hydrogen content and a low carbon content is an ideal fuel for heat treatment a gas of this kind can be manufactured. In other words, whatever is found from research work, to be the ideal fuel for heat treatment within certain limits, such a gas can be manufactured and will perform with the least possible amount of scaling. In particular cases such as the making of a highly specialized product resource is always had to the muffle type furnace where the flue gases do not come in contact with the metal.

Summarizing, it is found that a consideration of the ideal fuel for the heat treatment of steel must be of the following nature: In the first place the fuel must be permanent so that all our future developments and furnace installations can be utilized for many years to the greatest possible extent. In the second place, the fuel must have a high efficiency of utilization. It must be a fuel that will heat the metal with absolute uniformity in the minimum amount of time. Then again the effect of the flue gases of the fuel or the oxidation of the metal is an important factor. It must be a fuel which can be so manufactured and utilized to give a minimum of scale and not to effect economic production seriously. Then again such a fuel as is best suited for industrial operations should be somewhat allied with the developments of all our fuel resources so that ultimately fuel manufacture can be standardized and produced at large central stations. This means enormous production, distribution and utilization, in other words, a cheap fuel. A fuel that approaches all the requirements of this ideal fuel is blue water gas. It is permanent; it has the highest efficiency of utilization and its manufacture can be varied so that it will cause less scale than any other fuel. Coupled with this fact is the tendency toward the development of a similar fuel by public utility gas companies. Oil for gas making is rapidly disappearing. The B.t.u. value of the gas is being steadily lowered by public service commission regulations and gas consisting of a mixture of coal gas and blue water gas is rapidly becoming the universal fuel. Ultimately a much lower B.t.u. gas will be adopted. Such a gas will be essentially a blue water gas and will be universally applied to all heating operations.

INDUSTRIAL SIGNIFICANCE OF STANDARDIZATION

STANDARDIZATION stabilizes production and employment, since it makes it safe for the manufacturer to accumulate stock during periods of slack orders, which he cannot safely do with an unstandardized product.

2. Reduces selling cost. This is generally overlooked. Possibilities of reduced costs are generally even greater in distribution than in production.

3. It enables buyer and seller to speak the same language, and makes it possible to compel competitive sellers to do likewise.

4. In thus putting tenders on an easily comparable basis, it promotes fairness in competition, both in domestic and in foreign trade.

5. It lowers unit costs to the public by making mass production possible, as has been so strikingly shown in the unification of incandescent lamps and automobiles.

6. By simplifying the carrying of stocks, it makes deliveries quicker and prices lower.

7. It decreases litigation and other factors tending to disorganize industry, the burden of which ultimately falls upon the public.

8. It eliminates indecision both in production and utilization,—a prolific cause of inefficiency and waste.

9. By concentrating on fewer lines, it enables more thought and energy to be put into designs, so that they will be more efficient and economical.

10. By bringing out the need of new facts in order to determine what is best, and to secure agreement on moot questions, it acts as a powerful stimulus to research and development,—and it is thus in decided contrast to crystalization resulting from fixity of mental attitude.

11. It is one of the principal means of getting the results of research and development into actual use in the industries.

12. It helps to eliminate practices which are merely the result of accident or tradition, and which impede development.

13. By concentration on essentials, and the consequent suppression of confusing elements intended merely for sales effect, it helps to base competition squarely upon efficiency in production and distribution and upon intrinsic merit of product.

14. Standardization is increasingly important for the maintenance and development of foreign trade. There is strategy in nationally recognized "American" specifications.

15. The efficiency of competing countries, increasing through national standardization programs, is liable to transfer competition from foreign markets to our own shores.

16. Joint effort in bringing about standardization within and between industries almost invariably leads to better understanding and to beneficial co-operation along other lines,—a step toward the integration of our industries.

From a bulletin issued by the American Engineering Standards Committee, 29 West Thirty-ninth street, New York.

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Heat Treaters

By H. E. Gladhill

CARBONIZING

CARBONIZING IN FUSED SODIUM CARBONATE. By W. A. Jayme, *Forging & Heat Treating*, Vol. VII, Page 507.

The object of the experiments reported was to study the case carbonizing of steel in fused sodium carbonate when (a) the piece is simply immersed in the bath, (b) the steel acts as a cathode in the fused bath, (c) the steel acts as anode in the fused bath and (d) the steel is neutral the bath acting as an electrolyte. In case (a) no carburizing action was noted. In (b) a case of eutectoid composition was obtained. In (c) the erosion of the steel was too rapid for any satisfactory carbonizing action. In (d) the carburizing action was too slight to be of any practical importance. On the basis of the present experiment the results obtained do not indicate that the method would be of commercial importance.

EFFECT OF HEAT TREATMENT ON PHYSICAL PROPERTIES

URANIUM STEELS. By H. S. Foote, *Chemical & Metallurgical Engineering*, Vol. 25, Page 789.

Uranium in quantities under 2.0 per cent has little effect on the transition points. Increasing the uranium to 6.97 per cent produces an austenitic steel. The uranium occurs associated with the carbide. Photomicrographs of several grades of uranium steel are shown. Small amounts of uranium have a very marked influence in increasing the physical properties of steel. The following table gives a comparison with other steels:

Composition Per Cent	Elastic Limit Pounds per Square Inch	Tensile Strength Pounds per Square Inch	Elong. in 2 in. Per Cent	Reduction of Area Per Cent
Carbon 0.32, uranium 0.22	154,800	162,800	15.5	59.3
Carbon 0.30, nickel 3.5	111,000	124,000	15.5	53.3
Carbon 0.30, chromium 0.95, vanadium 0.18	146,200	162,700	15.0	57.0
Carbon 0.28, chromium 0.85, molybdenum 0.37	154,000	165,000	15.0	58.5

Uranium nickel steels show excellent properties and high speed steel is said to be benefited by the addition of uranium.

HARDNESS VARIATIONS IN HEAT TREATED STEEL. By C. R. Hayward, *Chemical & Metallurgical Engineering*, Vol. 25, Page 695 (1921).

It has been the author's experience that heat treated ¾-inch steel is generally harder in the center than at the edge. Several experiments on ¾-inch, 0.40-0.45 per cent carbon bar stock are cited. Differences of from 2 to 8 Shore hardness numbers were noted. An adequate explanation of this phenomena awaits further careful research.

HEAT TREATMENT IMPROVES STEEL CASTINGS. By M. M. Rock, *The Foundry*, Vol. XLIX, Page 797.

No standard practice is at present in existence for the annealing of steel castings. Tests were made to determine the efficiency of various heat treatments. Those studied were: (a) water quenching after four hours soaking at 1650 degrees Fahr. followed by drawing at 1220-1250 degrees Fahr.; (b) air cooling after four hours soaking at 1650 degrees Fahr. followed by drawing at 1220-1250 degrees Fahr.; and (c) annealing four hours at 1650 degrees Fahr. and furnace cooling.

Tensile tests showed little improvement in tensile properties due to the heat treatment. Tests made with the Russel, Izod and Charpy impact machines showed the heat treatment produced marked improvement. Tables of data are given.

THE "CHARACTERISTIC CURVES" OF THE HEAT TREATMENT OF STEELS. By A. M. Portevin and P. Chevenard. Read at the Paris meeting of the Iron and Steel Institute, *Engineering*, Vol. CXII, Page 551.

The results of heat treating steel are largely determined: (a) by the temperature to which the steel was heated and (b) the rate of cooling. By using these two variables as co-ordinates it is possible to draw curves showing the limits of annealing, and partial and maximum hardening conditions. These are the "characteristic curves." In order to obtain these curves it is necessary to determine accurately the "final state" of the steel. This is accomplished by dilatometric measurements during cooling and by the determination of Brinell hardness of the sample. Data has been established for several common industrial types of steel. Results are plotted for a steel of the following composition: carbon 0.50; manganese 0.30; nickel 2.65; and chromium 1.65 per cent. The above mentioned curves coupled with a knowledge of the cooling capacity of the quenching medium makes possible an accurate prediction of the influence of mass on the effects of heat treatment.

AN EXPERIMENTAL INVESTIGATION OF THE MECHANICAL PROPERTIES OF STEELS AT HIGH TEMPERATURES. By E. L. Dupuy, Iron and Steel Institute, Read at the September meeting in Paris.

The investigation covers steel running from 0.15 to 1.25 per cent carbon and a temperature range extending from room temperature to the melting point of the alloys. The breaking strength and reduction of area taken as characteristic of the physical properties. Both rolled and cast metals are used. The data is presented in the form of curves. In general the breaking strength curves show a maximum at 300-350 degrees Cent. from which the strength falls off to zero at the melting point. The reduction of area curves show a low point at 300-325 degrees Cent. and rise to 100 per cent between 1000 and 1250 degrees Cent. At the melting point the reduction of area curves also drop to zero.

STRUCTURAL PROPERTIES OF METALS AND ALLOYS. By R. W. Woodward, *American Machinist*, Vol. 55, Pages 596-599 and 636-638.

The author points out the necessity for understanding the possibilities and limitations of the various metals. The various physical properties, including thermal, magnetic and optical properties are taken up and tables of data are given for all of the common metals. No new data is submitted.

HEAT TREATING EQUIPMENT AND PRACTICE

COOLING OIL FROM QUENCHING TANKS. By S. E. Derby, *Forging & Heat Treating*, Vol. VII, Page 528.

An oil cooler is described and tables and curves are given showing the rate of heat transference from oil to water.

A NEW HEAT TREATING PLANT FOR MOTOR PARTS. By C. A. Armstrong, *Forging & Heat Treating*, Vol. VII, Page 515.

This is a description of the Milwaukee plant of the Nash Motors Co.

FEATURES OF ELECTRIC TOOL STEEL PRACTICE. By W. J. and S. S. Green, *Iron Age*, Vol. 108, Page 1061.

The authors recommend that tool steel manufacturers specialize as far as possible on ingot size. For carbon tool steel the larger the ingots the better. The melting shop should concentrate on production as far as possible and leave experimenting to other forces. The development of the electric furnace in the tool steel industry is followed and its products compared with the crucible process.

METALLOGRAPHY AND HARDNESS THEORY

A NEW ETCHING REAGENT FOR CHROME AND TUNGSTEN STEELS. By Karl Daeves, *Stahl and Eisen*, Vol. 41, Page 1262.

The use of an etching medium composed of potassium ferricyanide (20 gr.)

sodium hydroxide (10 gr.) and water (100 gr.) is described. Its use is restricted to high chrome and to high speed steel, ordinary low chrome structural steels not being etched.

THE MICROSCOPIC STUDY OF THE STRUCTURE OF METALS. By H. S. Rawdon, *American Machinist*, Vol. 55, Page 659.

The value of metallographic inspection in testing materials is developed. The use of the microscope is described and a large number of characteristic photomicrographs shown.

MIXED ORIENTATION DEVELOPED IN CRYSTALS OF DUCTILE METALS BY PLASTIC DEFORMATION. By E. C. Bain and Zay Jeffries, *Chemical & Metallurgical Engineering*, Vol. 25, Page 775.

From X-ray spectrographs the effects of cold work are elucidated.

THE AMORPHOUS METAL HYPOTHESIS. By Zay Jeffries and R. S. Archer, *Chemical & Metallurgical Engineering*, Vol. 25, Page 697.

The amorphous cement hypothesis and its applications to plastic deformation are explained.

STRENTHENING METALS BY COLD-WORK. *Chemical & Metallurgical Engineering*, Vol. 25, Page 697.

An exposition of Prof. E. Heyn's views on the hardening theory is given.

SOME UNUSUAL STEELS

DAMASCENE STEEL AND ITS ORIGIN. By Col. N. T. Belaiew, *Blast Furnace and Steel Plant*, Vol. 9, Page 621.

Damascene steels are hyper eutectoid carbon steels containing about 1.5 per cent. Through a careful forging process the cementite is thoroughly spheroidized. The microstructure is very similar to high speed steel and similarities in treatment are pointed out.

NON-MAGNETIC, ACID AND RUST-RESISTING STEEL. *Chemical & Metallurgical Engineering*, Vol. 25, Page 797.

The properties of a steel called "Resistal," developed in the research laboratory of the Crucible Steel Co. of America, Pittsburgh, giving its physical and acid resisting properties, are described.

TESTING INSTRUMENTS

INSTRUMENT TO MEASURE ELONGATION OF BROKEN TENSILE SPECIMENS. By R. W. Woodward, *Chemical & Metallurgical Engineering*, Vol. 25, Page 756.

An instrument is described which is direct reading. The bars are held by center points and per cent elongation in two inches is read from a dial attached to one of the index points.

THE USE OF THE SCLEROSCOPE ON LIGHT SPECIMENS OF METALS. By F. S. Tritton, *Engineering*, Vol. CXII, Page 492.

Samples of metal weighing considerably less than a pound do not give the same reading on the scleroscope as samples of identical properties weighing over a pound. Clamping in a vice does not improve the practice. The readings are from 80 to 35 points low for the light pieces of metal. By mounting the light specimens on pitch in a clamp designed by Rosenhain the readings may be made to check. Mounting the specimens on steel blocks weighing a pound by means of glucose also gave satisfactory results.

NEW MEMBERS' ADDRESSES OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A represents Associate Member; S represents Sustaining Member; J. represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

BACH, A. D., JR., (A-11), Atlas Crucible Steel Co., 1028 Hanna Bldg., Cleveland, Ohio.
BOYNTON, HENRY C., (M-11), John A. Roebling's Sons Co., Trenton, N. J.
BROWN, CHAS. M., (A-11), Colonial Steel Co., Pittsburgh, Pa.
BURRILL, PERCY J., (A-11), 114 Arlington St., Youngstown, Ohio.
CASSIDY, A. G., 536 5th Ave., N., St. Petersburg, Fla.
DAILEY, J. B., (M-11), 131 Porter St., Dearborn, Mich.
DASSE, FRANK H., (M-11), 804 Wisconsin Ave., St. Joseph, Mich.
HAMLEY, T. G., (M-10), Cleveland Wrought Products Co., West 58th S. of Denison, Cleveland, O.
HILE, LESLIE M., (M-11), 661 Broadway St., Benton Harbor, Mich.
JACOBSEN, O., (M-11), 917 Harvard Blvd., Dayton, Ohio.
JOHNSON, F. C., (M-11), 2618 Kirby Ave., W., Detroit, Mich.
KITFIELD, E. B., (A-11), 88 Pine St., Wallingford, Conn.
KLEIN, STANLEY C., (M-10), 27 Rhodes Ave., S. Charleston, W. Va.
NAISH, A., (M-11), 142 Dutton Ave., San Leandro, Cal.
POLDI STEEL WORKS, (Sb.-11), 17 Palackeho Trida Prague-Vinohrady, Czecho, Slovakia.
ROWELL, W. E., (M-11), 7400 Paxton Ave., Chicago, Ill.
SHIRAI & CO. INC., (Sb.-11), 291 Broadway, New York City.
TYMES, H. W., (M-11), 1466 Broadway, Watervliet, N. Y.

CHANGES OF ADDRESS

ANGER, EARL M.—from Liberty Steel Corp., Box 12, Morristown, N. J., to Crystal, Conn.
ARMET, LESLIE R., MGR.—from 815 Hickory St. to 3732 Bamberger Ave., St. Louis, Mo.
BALDWIN, JAS. P., (M-1)—from 66 Forest St. to 272 Corbin Ave., New Britain, Conn.
BEAUMONT, J. S., MET.—from P. O. Box 724 to P. O. Box 501, Walkerville, Ont., Canada.
BELLIS, C. B., (M-8)—from 173 West Rock Ave. to 335 Winthrop Ave., New Haven, Conn.
BLISS, I. R.—from Atlas Crucible Steel, 3567 Lindell Blvd. to 3850 Westminster Ave., St. Louis, Mo.
BOURRASSA, A. A.—from 2428 Tremont Ave. to 2134 Farnam St., Davenport, Iowa.
BOYER, SHERMAN H.—from 311 Hubbard Ave. to 1065 Hubbard Ave., Detroit, Mich.
BULL, IRVING C.—from Bull & Roberts, 100 Maiden Lane to 50 West St., New York City.
CANNON, J. D.—from 622½ Fifth Ave., Milwaukee, Wis., to 129 2nd St., New Castle, Del.
CASSELMAN, F. J., SUPT.—from The John Steptoe Co., 2951 Colerain Ave., to 3206 Colerain Ave., Oakley, Cincinnati, Ohio.
GALLAHER, RAY C.—from 50 Huffman Ave., to 1004 Haynes, Dayton, Ohio.
GEISSINGER, H. G. (A-4)—from H. L. W. Mfg. Co., 20th & Fort to 411 Kresge Bldg., Detroit, Mich.
GILGER, GEORGE A. JR.—from 207 Catherine St. to 360 Cortland Ave., Syracuse, N. Y.
GRENON, JOSEPH A., (M-12)—from 12 Leversque Ave., Hartford, Conn., to 45 Lakeside Ave., Marlboro, Mass.
HARDY, CHAS.—from 50 Church St., to 115 Broad St., N. Y.
HARR, DAVID P.—from Hotel Stevenson, 46 Davenport, to 1350 E. Jefferson Ave., Detroit, Mich.

HARRIS, S. A., MET.—from Jas. H. Herron Co. to 2079 E. 46th St., Cleveland, O.
HOBBS, ALFRED, (M-11)—from 529 Delaware St. to 300 Parkway Dr., Syracuse, N. Y.
HOUSER, GEO. B., (M-10)—from 416 Renwich Ave. to 317 Burt St., Syracuse, N. Y.
HOYT, SAMUEL L.—from Nela Park, Cleveland, to Brown Ave., Willoughby, Ohio.
JOHNSON, S. S.—from Pelton Steel Co. to Milwaukee Steel Foundry, Milwaukee, Wis.
KERNOT, A. H., (M-3)—from 103 Marquette Ave. to 829 Van Buren, South Bend, Ind.
KIMMEL, GEO. C.—from The Cincinnati Grinder Co., 3233 Colerain Ave., Cincinnati, Ohio to Murbury & South Aves., Oakley, Cincinnati, Ohio.
KRUGER, LOUIS P.—from Angsten Kox Co. to P. O. Box 256, Michigan City, Ind.
LARDNER, JAS. F. JR.—from Y. M. C. A. to John Deere Plow Wks., Moline, Ill.
MACKENZIE, WM. J.—from 5227 Woodlawn Ave. to 5338 Blackstone, Ave., Chicago, Ill.
MILLER, JOSEPH J.—from 601 Bailey Farrel Bldg., Pittsburgh Pa. to Gulic, Henderson Co., Inc., 525-529 3rd St., Pittsburgh, Pa.
NEWBOLD, L. T.—from 1853 Newton St., N.W., Washington, D. C. to University of Cincinnati, 140 W. University Ave., Cincinnati, Ohio.
POLHEMUS, G. JULES—from 1238 40th St., West Washington Blvd. to Ludlum Steel Co., Peoples Gas Bldg., Chicago, Ill.
PUTNAM, A. H.—from P. O. Box 653 to 1710 E. 12th St., Davenport, Iowa.
RAWSON, ROLLIN—from 2280 E. 93rd St. to 2163 E. 87th St., Cleveland, O.
REYNOLDS, C. M.—from 311 Main St. to 475 Shrewsburg St., Worcester, Mass.
RUDDELL, ROBERT J.—from 311 Hubbard Ave. to 1065 Hubbard Ave., Detroit, Mich.
SCHNEID, R. A., (M-12)—from 569 Bryant Ave. to 263 Tennyson Ave., Syracuse, N. Y.
TARBOX, GURDON, (M-9)—from Spicer Mfg. Co. to 425 E. 7th St., Plainfield, N. J.
THOMSON, W. G. H. (M-10)—from 1455 W. 37th St. to P. O. Box 263, Rockford, Ill.
TIFFNEY, GEORGE E., (M-11)—from Colts Patent Fire Arms Co. to 683 New Britain Ave., Hartford, Conn.
TOUR, SAM—from 1340 Gillatin N. W., Washington, D. C. to 2225 Ditmas Ave., Brooklyn, N. Y.

MAIL RETURNED

BASTION, WM., 709 Avery Ave., Syracuse, N. Y.
KMAN, GEORGE, (M-4), 855 W. 51st Pl., Chicago, Ill.
LANFER, EMIL, 315½ Genesee St., Syracuse, N. Y.
WOLFE, H. S., (M-3), 726 Pembroke Rd., Bethlehem, Pa.

News of the Chapters

ELECTED DEAN OF SCHOOL OF FOREMANSHIP

THE *Rocky Mountain News* of Denver contains a write-up and photograph of T. E. Barker, formerly first vice president of the American Society for Steel Treating, as follows:

"T. E. Barker, general superintendent of the Denver Rock Drill Company, has been elected dean of the new school of foremanship which is to be organized at the Y. M. C. A. next Wednesday evening. A committee of personnel managers and superintendents of a number of the leading shops of the city is co-operating with the Y. M. C. A. schools in putting on this course.

"While this course is intended largely for foremen and assistant foremen in establishments having production departments, it also is intended that it shall be of service to men in any industry in which a study of personnel problems will be of advantage. This course will cover a period of four months.

"Dean Barker will select a number of experts in this field here in Denver to assist him in giving instruction. It is expected that a number of industries will assist their foremen and assistant foremen to attend this course by paying a part of the tuition."

PROVIDENCE CHAPTER

The November meeting was addressed by Victor E. Hillman, metallurgist for Crompton & Knowles Loom Works, Worcester, Mass. His subject "The Efficiency of Different Mixtures for Cyanide Hardening, and the Role of Nitrogen in the Process", was illustrated by lantern slides. The meeting was of special interest from a practical point of view, was quite well attended, and proved to be very interesting.

CLEVELAND CHAPTER

President F. P. Gilligan paid his first official visit to this chapter on Thursday evening, Oct. 28, when over 100 members and friends met at the Engineering Society's rooms at the Winton Hotel. President Gilligan presented a talk on "Alibis for the Hardening Room" which proved to be very acceptable. The address was well illustrated.

In addition to President Gilligan, a number of other National Officers were present, having arrived in Cleveland to attend the meeting of the Board of Directors on Oct. 29.

PHILADELPHIA CHAPTER

Over 100 attended the regular meeting of the Philadelphia Chapter held at the Engineers' Club on Oct. 28. T. Holland Nelson presented a very interesting paper on the subject of "Comparison of English and American Methods of Manufacture of Crucible Steel." The paper was profusely illustrated and as the subject indicates, gave a comparison on the different methods of manufacture.

TRI CITY CHAPTER

The Tri City Chapter has prepared a special announcement of a series of practical and technical talks to be given on the Thursday following the first Monday of each month. These talks will be presented by men of national prominence who have made their subjects a specialty, and who are thoroughly capable of presenting them in a manner which will be readily understood.

SPRINGFIELD CHAPTER

Quite a large number of members gathered at the Chamber of Commerce on Nov. 18 to hear H. J. N. Voltman, of the W. S. Rockwell Co., New York City, present an interesting illustrated lecture on "Equipping and Laying-Out the Heat Treating Department of a Small Industrial Plant". Mr. Voltman is an authority on the subject of heat treating equipment and his talk was of the same high standard he has maintained in the many excellent publications issued by this firm.

Arrangements were also made for visitation to the Rolls-Royce automobile plant.

BOSTON CHAPTER

A. H. d'Arcambal, chief metallurgist of the Pratt & Whitney Co., Hartford, presented an illustrated paper on "High Speed Steel" before the Boston Chapter in Room 1 of the Boston City Club on Nov. 18. Mr. d'Arcambal is an authority on high speed steel. The discussion following the presentation of his paper was very heartily entered into by the large number present. While Mr. d'Arcambal was in Boston, he addressed the mechanical engineers of the Massachusetts Institute of Technology.

NEW YORK CHAPTER

The New York Chapter has made arrangements for the use of a lecture room at the Engineering Societies Building, and its meetings in the future will be held there. The Program Committee consisting of Mr. Graham, Chairman, and Mr. Thum and Mr. Fishback, members, has planned a very interested series of meetings for the year.

On Nov. 16, T. H. Nelson, works manager of H. Disston & Sons, Philadelphia, presented a very interesting paper of the manufacture of tool steel. Dr. Federico Giolitti, the eminent Italian metallurgist and international authority on case hardening, was a guest of honor at this meeting.

The practical talks for the 1921-22 season are as follows:

DECEMBER:—What happens to steel when you heat and quench it.

JANUARY:—Annealing and tempering machine and tool steels.

FEBRUARY:—Case hardening (carburizing and subsequent heat treatment). Ways of doing it, and what it does to a piece of steel.

MARCH:—Treatment of high speed steel.

APRIL:—Hardening room troubles, shrinkage, warpage and scaling.

MAY:—Up-to-date hardening room equipment, furnaces, pyrometers and auxiliaries.

JUNE:—Spotting the reason for failures in service. Practical uses for microscopes and physical testing machines.

Added Attraction:—Current events, a 10-minute talk at each meeting on recently published items of interest to heat treaters. Come to the meetings and get into the discussions of the topic presented.

HARTFORD CHAPTER

The Hartford Chapter held its November meeting in Jewell Hall, Y. M. C. A. on Nov. 10. A paper on "Case Hardening" was presented by Stanley P. Rockwell, consulting metallurgist. Mr. Rockwell handled his subject in a very capable manner due to his wide experience acquired while in the employ of firms doing carburizing on a large scale. Mr. Rockwell described the advantages and disadvantages of the various treatments and materials used in commercial operations. About 120 were present, and there was considerable discussion.

R. K. Newman, of the Frasse Steel Co., Hartford, Conn., described a recent application of a chrome-tungsten steel to a difficult die job, as well as telling of the "Jones" test which was used to guide in the selection of the proper heat treatment.

The December meeting will be held on Thursday, Dec. 8, at Jewell Hall. The paper "Spring Manufacture" will be presented by George P. Moore who directs the metallurgical work at the Wallace Barnes Co., of Bristol. Many of the methods of this industry were originated by this company and they still maintain an active leadership in the development of new and up-to-date processes.

ST. LOUIS CHAPTER

Due to the illness of Mr. Maher, Chairman of the St. Louis Chapter, his resignation was presented and accepted with regret. Fred Key, manager of the St. Louis Pressed Steel Co., 27th and McCausland avenues, E. St. Louis, Ill., was selected as chairman of the Chapter.

The November meeting was held on Nov. 10 at the Engineers' Club room. W. S. Bretschneider, of the Norton Company, spoke on the "Selection of Grinding Wheels for the Tool Room." As a special feature, Charles LeCompte gave a chalk talk. The meeting was very well attended and proved to be most interesting.

DETROIT CHAPTER

C. H. Heilman gave an interesting talk on "Correlation Between Testing of Materials and Service" to 125 members and friends of the Detroit Chapter who gathered at the Board of Commerce rooms. The discussion was excellent and was entered into with great enthusiasm by the men present.

CHICAGO CHAPTER

A practical discussion of shop problems was entered into by 120 members who gathered at the City Club on Nov. 10. These meetings have always been decidedly popular with the Chicago membership, and many questions were presented and discussed at this meeting.

ROCHESTER CHAPTER

The Rochester Chapter held its November meeting in the Engineering Society Club rooms on Wednesday, Nov. 9. Robert Smith, of E. F. Houghton & Co., presented a paper on "Quenching Mediums" and Lloyd K. Marshall, chairman of the Chapter, presented his paper on "Tool Steel Manipulation", that he prepared and presented at the Indianapolis Convention. Both papers were of much interest and caused a large amount of discussion.

SYRACUSE CHAPTER

About 100 members gathered in the ball room of the Yates Hotel to attend the November meeting of the Syracuse Chapter. George M. Berry, chief chemist of the Halcomb Steel Co., presented an interesting talk illustrated with lantern slides on the subject, "From Ore to Steel". Mr. Berry presented his paper in an excellent manner, and the meeting proved to be a very enjoyable one. A buffet luncheon was served at the close of the meeting, which assisted in adding to the enjoyment of the occasion.

SCHENECTADY CHAPTER

The November meeting of the Schenectady Chapter was addressed by T. S. Fuller, metallurgist of General Electric Co., on the subject, "Corrosion of Iron and Steel". The rust problem is one in which all the members were interested, and Mr. Fuller's collection and presentation of the material on this subject as well as his own special study of corrosion combined to make the evening a very profitable one.

Entertainment features were furnished by A. Decrenzo, pianist, and W. Melber, baritone, gave several selections. An orchestra was also in attendance, and gave a number of selections.

WORCESTER CHAPTER

The Worcester Chapter has adopted the policy of mimeographing the discussions held upon the papers presented at their meetings. The first of these mimeographed discussions was upon the paper presented by Wheaton B. Byers, on the subject of "Carburizing". Three very interesting pages of discussion were collected at this meeting, and mailed to the membership.

SOUTH BEND CHAPTER

The October meeting of the South Bend Chapter was held Oct. 13 at the Y. M. C. A. The "Studebaker Industrial Films" were shown and this was followed by a talk by Mr. Freydendahl, of the Chicago Flexible Shaft Co., on the "Principles of Combustion", as applied to furnaces. About 60 attended the meeting.

Mr. W. R. Newhouse has been appointed chairman of the organization committee.

The Chapter held its regular meeting on Nov. 8 at the Y. M. C. A. building. In spite of the meeting falling on election night and in spite of a violent combination rain, hail and snow storm, 55 members and guests attended the meeting. Due to the fact that the Chapter has a number of foundrymen as members and also to the fact that there are a large number of foundries located in that territory, the usual program was departed from by securing as speaker for the evening, Clement A. Hardy, of the Clement A. Hardy Co., of Chicago, engineers of design and operation of foundries and allied industries. Mr. Hardy chose as his subject, "Common Sense Foundry Engineering". He first discussed the points to be taken into consideration in building a foundry and followed up by a series of slides of the new foundry of the Fairbanks, Morse Co., at Beloit, Wis. This is a foundry designed to produce 500

tons of castings per day. His paper was followed by a discussion which dealt with everything from building material to analysis of iron used in the different types of castings.

It was the opinion of most of those attending the meeting that it was one of the most successful meetings ever held. As the success of the Chapter depends on getting the shopmen interested it will be necessary to follow this up with practical talks on the various methods of manufacture of steel and its products.

WASHINGTON CHAPTER

Owing to changes in business connections of several members of the Washington Chapter there have been changes in the personnel of committees and in Chapter officers as follows: Chairman, H. J. French, division of metallurgy, Bureau of Standards, Washington, D. C.; Vice Chairman, W. L. Blankenship, U. S. Navy Yard, Washington, D. C.; Secretary-Treasurer, J. Straus, U. S. Navy Yard, Washington, D. C.; and Chairman of Meetings Committee, J. S. Vanick.

Mr. Tour, former chairman of the Chapter has gone to Brooklyn, N. Y., and H. E. Handy, former chairman of the Meetings Committee, expects to leave Washington in the near future. Both men expressed regret at leaving the local section and only resigned their respective connections with the Chapter because of removal from the city.

The next meeting will be held on Nov. 18 and meetings will hereafter take place on the second Friday of each month. At the next meeting a motion picture will be shown depicting the manufacture of American ingot iron and a short paper will be presented by J. S. Vanick on "Nitrides in Steels".

LEHIGH VALLEY CHAPTER

The Lehigh Valley Chapter held the second meeting of its series on "The Manufacture, Treating and Testing of Steel" at the Battery Building of the Bethlehem Steel Co., Nov. 7. The feature of the meeting was an illustrated talk given by B. H. DeLong, metallurgist of the Carpenter Steel Co., Reading, Pa., on "The Manufacture of Tool Steel".

Mr. DeLong portrayed with slides and explained in detail every operation employed in the manufacture of high-grade tool steels. Beginning his lecture, Mr. DeLong gave a brief history of iron and steel and stated that iron was known to have been used 3500 years B. C. and that steel saws which had been tempered were found underneath the pyramids, these having been made 800 years B. C. Describing the processes employed in the making of weapons of warfare down through the ages, Mr. DeLong said that even the Damascan swords could in no way be compared to the quality of high-grade steels manufactured today.

In discussing the electric furnace and open-hearth processes of melting steel as compared with the crucible process, the speaker pointed out that for quality steel the crucible process was to be preferred. The practice of pouring the steel directly from the crucibles into the ingot moulds was discussed also and Mr. DeLong explained that the method employed by the Carpenter Steel Co. of pouring from the crucible into a large ladle and then pouring the ingots from the ladles produced a cleaner and uniformly better steel.

Throughout his entire talk Mr. DeLong emphasized the importance of the human element and how necessary skilled and competent workmen were to the production of high-grade tool steel. Mr. DeLong proved

to be a speaker of exceptional ability. He was thoroughly acquainted with every phase of his subject and delivered it in a manner which made it very highly interesting as well as instructive.

Before and after the lecture the members took advantage of and were much interested in the Bethlehem Steel Co.'s exhibit at the Battery Building and it was at a late hour when the meeting adjourned. It was announced at the meeting that Frank P. Gilligan, newly elected President of the National Society, would be with the local Chapter at its next meeting to be held Nov. 28.

NORTH WEST CHAPTER

The following item of interest has been taken from the *Weekly Bulletin* published by the Manufacturers' Club of Minneapolis:

The first lecture in the Educational Course on Steel Treating will be held Monday evening, Oct. 24, at 8:00 o'clock, at the Club rooms, Chairman O. E. Harder, Professor of metallography at the University of Minnesota, will present the subject of "Composition, Elements and Classification of Steels, together with their meaning," which will be illustrated by lantern slides. The lecture will consume about an hour and will be followed by a general discussion led by members of the Executive Committee.

These educational lectures, nine in all, will be held on the fourth Monday of each month, and will cover in a nontechnical way the fundamentals of metallurgy and steel treating. They will be of exceptional interest to every one engaged in the iron and steel line.

H. K. Briggs, Minneapolis Electric Steel Castings Co., Chairman of the Educational Committee, is very much gratified at the way member concerns of The Manufacturers' Club are supporting this course. Already 73 men have been enrolled, none of whom are members of the Steel Treaters' Section. The Woolery Machine Co. will undoubtedly have the largest representation as H. E. Woolery has enrolled 12 of his men for the entire course. He says he is willing to gamble a dollar that each of them will receive manifold returns.

Chester S. Moody, Minneapolis Steel & Machinery Co., Chairman of the Meetings and Papers Committee, has announced the following program for the first meeting in each month:

November—Mr. Belleville, vice president, Commonwealth Steel Co.
Subject: "For the Good of the Commonwealth, or The Inside of the Electric Furnace." Three reels of motion pictures.

December—Mr. Farquhar, metallurgist, Electric Steel Co. of Indiana.
Subject: "Electric Steel."

January—C. S. Spaulding, metallurgist, Halcomb Steel Co., Syracuse, N. Y.
Subject: "A Comparison of the Rate of Penetration of Carbon in the Various Commercial Steels in Use for Case Carburizing." Illustrated.

February—A. H. D'Arcambal, metallurgist, Pratt & Whitney, Hartford, Conn.
Subject: "Physical Tests on High Speed Steel." Illustrated.

March—H. A. Schwartz, director research, National Malleable Castings Co.
Subject: "American Malleable Iron."

April—C. P. Richter, Central Steel Co., Massillon, Ohio.
Subject: "Steel for Gears."

May—O. T. Muehlmeyer, metallurgist, Barber-Coleman Co., Rockford, Ill.
Subject: "Steel Dies."

June—To be arranged. Probably a picnic.

The foregoing program has been arranged in conjunction with other chapters of the American Society for Steel Treating. Exact dates of the meetings will be announced as soon as they are fixed.

Another write up in the same publication was as follows:

"The first lecture in the educational course conducted by this Section was held Monday evening Oct. 24th, in the Club rooms. Approximately 125 were present, including members and those enrolled for the course which was most gratifying to the committee in charge.

Chairman O. E. Harder discussed the "Composition and Classifications of Steels and Their Meanings," which was illustrated by lantern slides. An 11-page

brief, summarizing the lecture, has been prepared for distribution. Copies may be obtained without expense by any one who is interested, upon application at this office.

Mr. Harder in his introduction, as showing the range and variety of the subjects to be handled in this course, said:

The subject-matter to be given in this series of lectures will include a somewhat broader field than that usually referred to as steel; for example, it will include cast iron, malleable cast iron, semisteel, and wrought iron, as well as various kinds of straight carbon and alloy steels. It will be the purpose of this first lecture to outline in a general way, and show by a diagrammatic summary, the various steps in the production of the materials mentioned above from the iron ore. The blue print included in the notes covering this lecture will make it possible to follow the various steps in the production of many types of finished products. They will be taken up in the following order: Cast iron, malleable cast iron, semisteel, wrought iron, cast steel, and steel. The latter term covers plain carbon steels, alloy steels, and high speed tool steels. Strictly speaking, these kinds of steels should be called wrought steel as a distinction from cast steel.

Ninety-seven men employed by member concerns have been enrolled in this course. The entire expense is but $1.00. Enrollments are still being accepted. The subjects covered include metallurgy as well as steel treating, and will be of exceptional value to those in the metal products line. If there is any one in your organization who may be interested, send his name to this office, and he will be placed upon the enrollment list. He will also be privileged to attend the regular meeting of the Section held monthly, at which more technical subjects are discussed."

The regular meeting of the members of the Northwest Chapter was held Wednesday evening, Nov. 16, at The Manufacturers' Club, 200 Builders Exchange. Francis B. Foley, metallurgist for the United States Bureau of Mines, stationed at the Minnesota Section at the University of Minnesota, spoke on "Pyrometers."

Mr. Foley has had extensive experience in the field of pyrometry. He was engaged in research work for the Midvale Steel & Ordnance Co., of Philadelphia, from 1909 to 1917. From 1913 to 1917, he had charge of all the pyrometers in that important steel and ordnance plant. Since 1917 he has been engaged in a number of important investigations on war problems, researches for the National Research Council and for the U. S. Bureau of Mines. One of the important parts of his lecture was a thorough and comprehensive explanation of the principles of different classes of pyrometers.

Dinner was served as usual at 6:30, the business meeting commenced at 7:30.

Commercial Items of Interest

A BULLETIN issued by the American Engineering Standards Committee, 29 West Thirty-ninth street, New York, discusses industrial standardization work in Germany and emphasizes the point that insufficient attention has been given to the role which standardization is playing in German industrial reconstruction. Following are a few of the statements made in the report:

"The German industries are planning and are carrying out a far-reaching program of standardization as a necessary step in building up an unprecedented industrial structure which must rest in large measure on an extensive foreign trade. In no other country except Great Britain is standardization work being carried on upon a scale, or with an intensity, comparable to that in Germany. * * * It is remarkable that the national standardization movement in Germany should have been so thoroughly organized and that so much work should have been accomplished in four years. 144 approved standards sheets have been issued and over 500 others have been so far developed that they have been published in tentative form. * * * The standardization movement in Germany is particularly significant, since Germany is one of the three leading industrial countries. The industries of Austria, Holland, Sweden, and Switzerland, are so intimately related to those of Germany on account of geographical and other relationships, that they are necessarily affected very largely by developments in Germany. It appears that the work is being woven very intimately into the industrial fabric. The very large number of standards purchased by the industry, and the fact that the central organization has 5000 firms which are co-operating members, are a sufficient indication of this. There seems to be a striking analogy between the present standardization movement in Germany, and the research movement developed there a generation ago. Whatever estimate one may place upon the role it played in German industries generally, everyone agrees that research was fundamental in the development of their great chemical industries. The role which the Germans are expecting standardization to play in all their industries would be not unlike the role which research has played in their chemical work."

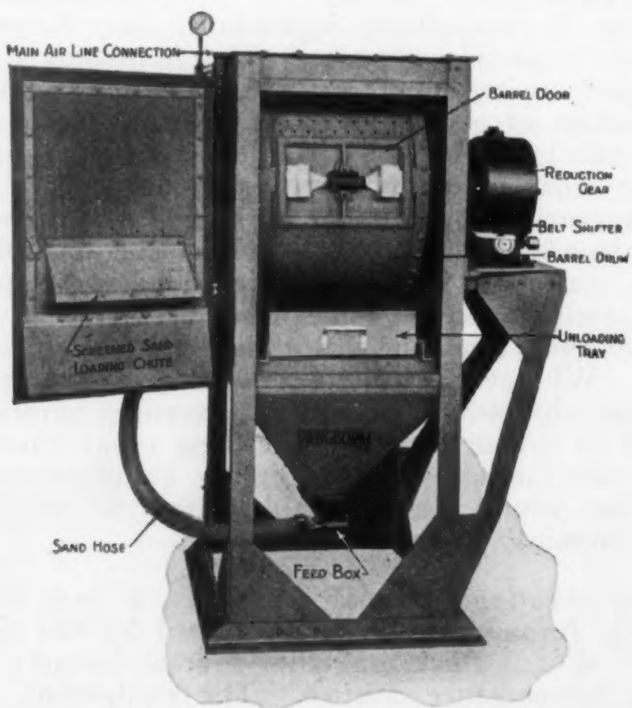
For the heat treating of small products, a new automatic, semi-cylindrical electric furnace has been developed by the General Electric Co., Schenectady, N. Y., which embodies several features contributing to the flexibility of temperature control. The equipment consists of the furnace, transformer automatic control panel, and a temperature control instrument mounted on the sub-base of the panel. The furnace consists of a sheet metal casing supported on legs and is lined with insulating material to form a semicylindrical chamber.

A continuous strip of resister ribbon shaped into an arch or succession of semicircular turns conforming to the arch of the furnace chamber and extending the whole length of the latter forms the heating element. Insulators between the turns provide a strong self-supporting winding flexible to expansion and contraction. The power cables are

attached to the back of the chamber. Heat is radiated direct to the charge, no muffle being used. By removing the front of the furnace and disconnecting the terminals at the back, the resistor may be pulled out bodily for inspection and repair.

Four coils form the primary of the transformer and may be connected in multiple, multiple series, or series for 110, 220 or 440 volts at 60 cycles. The secondary has two taps, one 70-volt giving 10 kilowatts for rapid heating and the other 50-volt giving 5 kilowatts for normal heating. The normal rating of the transformer is 7.5 kilowatts but 10 kilowatts may be obtained for short periods. The temperature control instrument has a scale range of 1000-2000 degrees Fahr. thus the furnace is protected from excess temperature. A special fuse melting at 1800 degrees Fahr. provides additional protection to the equipment.

For cleaning small heat treated pieces, the Pangborn Corp., Hagerstown, Md., has developed a small self-contained sand blast barrel. This device consists of a sheet metal, dust tight cabinet or housing on a structural steel frame, the bottom being hopper shape to receive the abrasive and equipped with a feed box to which is attached a hose that conveys the sand to the nozzle. The barrel drum, mounted within this cabinet or housing, is 24 inches diameter and 16 inches long and is con-



SAND BLAST BARREL FOR HEAT TREATED PARTS

structed of perforated sheet metal. It is revolved by gears connected to the main shaft. An opening at the other end receives the nozzle which is mounted on a swinging bracket to give easy access. Dust tight doors close the barrel housing and opening for the nozzle. Baffles inside the barrel drum turn the load as it rotates slowly, bringing all

pieces and faces under the blast action. The spent abrasive drops through the perforations of the drum into a screen tote box and through into the hopper for re-use. The equipment occupies a floor space of 2 feet 7 inches by 8 feet 6 inches and stands 5 feet 6 inches high.

Bulletin No. 240, issued recently by the W. S. Rockwell Co., 50 Church street, New York, and entitled "The Heat Treatment of Springs With Stationary and Continuous Furnaces," is an outline of the fundamental principles of heating and handling springs. It consists of eight pages and is made complete with illustrations showing cross sectional views of the various types of furnaces as well as practical installations. Much of the difficulty in the manufacture of springs is due to improper methods in the heat treating operations and the use of equipment and fuel not properly adapted to the manufacturing conditions. The purpose of the bulletin is to give information as to the application of principles which must be considered in improving the quality and decreasing the cost of springs and similar heat treated products.

According to an announcement appearing in the November issue of the Bulletin of the American Foundrymen's Association, the next convention and exhibit of the association will be held in Cleveland during the week of April 24, 1922. Headquarters and the exhibits will be in the new Cleveland Public Hall, at Lakeside avenue and East Ninth street, which is rapidly nearing completion. The Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers will hold its convention jointly with the foundrymen as has been the custom in past years. Of the cities considered, Cleveland is most centrally located for the membership, for the foundry industry, and for the manufacturers of foundry equipment and supplies who make annual exhibits, and its selection will conserve traveling and freight expense.

The powdered coal department of the Quigley Furnace Specialties Co., Inc., 26 Cortlandt street, New York, has been acquired by the Hardinge Co., 120 Broadway, New York. The latter company states no change will be made in the method of conducting the business at its offices, as the organization of the engineering department has been taken over practically intact. The transfer will not affect the refractory specialties business of the Quigley company, which includes the manufacture and sale of high temperature cement, insulating brick and other products. The rapid growth of this branch of business made it necessary that the company devote its entire attention to furnace specialties, with particular reference to refractory linings and the heat insulation of furnace structures.

A sales office has been opened at 134 South LaSalle street, Chicago, by the Interstate Drop Forge Co., Milwaukee, with Robert L. Peoples in charge.

Representation of the Ludlum Steel Co., Watervliet, N. Y., manufacturer of tool and special steels, in Wisconsin and Minnesota, has been taken by the Barber Iron & Steel Co., 329 West Water street, Milwaukee.

Stanley P. Rockwell, metallurgical engineer, 65 Highland street, Hartford, Conn., recently has announced his entrance into the consult-

(*Continued on Page* 34)

COMPARATIVE BRANDS OF

Compiled by Tool

COMPANIES	ADDRESSES	CRUCIBLE ANALYSIS TOOL STEEL
1. Atlas Crucible Steel Co.	1. Dunkirk, N. Y.	1. Atlas Common
2. Bethlehem Steel Company	2. Bethlehem, Pa.	2. Bethlehem X
3. Braeburn Steel Company	3. Braeburn, Pa.	3. Braeburn B T
4. Carpenter Steel Company	4. Reading, Pa.	4. Titan
5. Century Steel Co. of America	5. Poughkeepsie, N. Y.	5. Crucible Analysis
6. Colonial Steel Company	6. Pittsburgh, Pa.	6. Anchor
7. Columbia Tool Steel Company	7. Chicago Heights, Ill.	
8. Crucible Steel Co. of America	8. Pittsburgh, Pa.	8. Corona
9. Cyclops Steel Company	9. Titusville, Pa.	
10. Henry Disston & Sons, Inc.	10. Philadelphia, Pa.	10. Standard
11. Firth-Sterling Steel Company	11. McKeesport, Pa.	
12. Halcomb Steel Company	12. Syracuse, N. Y.	
13. Heller Brothers Company	13. Newark, N. J.	
14. Hess Steel Corporation	14. Baltimore, Md.	14. Hess Standard
15. Internat. High Speed Steel Co.	15. Rockaway, N. J.	15. Standard Tool
16. William Jessop & Sons, Inc.	16. New York, N. Y.	
17. Latrobe Electric Steel Co.	17. Latrobe, Pa.	
18. Ludlum Steel Company	18. Watervliet, N. Y.	18. Ludlum Carbon
19. Midvale Steel & Ordnance Co.	19. Philadelphia, Pa.	19. Mining Drill
20. Simonds Mfg. Company	20. Fitchburg, Mass.	20. Simonds No. 4
21. Vanadium Alloys Steel Co.	21. Latrobe, Pa.	21. Crucible Analysis
22. Vulcan Crucible Steel Co.	22. Aliquippa, Pa.	

SPECIAL TOOL STEEL	OIL HARDENING STEEL	ONE TO TWO PERCENT TUNGSTEN (INTRA) STEEL
1. Atlas XX	1. Deward	
2. Bethlehem XXX Special	2. Bethlehem Tool Room	
3. Braeburn Special	3. Braeburn Non-Shrinking	
4. Special	4. Stantor	4. K W
5. Red Label No. 42	5. Centaur No. 36	5. Wit-Edge No. 25
6. Colonial Special No. 14	6. Colonial Oil Hardening No. 6	6. Colonial Standard No. 5
7. Columbia Special	7. Columbia Oildie	
8. Atha Special Park Special Crescent Special Labelle Special Sanderson Special Howe-Brown Special Singer Special	8. Atha Non-Shrinkable Paragon	8. Champion Extra Viking Extra
9. Cyclops Special Tool	9. Cyclops Wando	9. Cyclops Para Steel
10. Special	10. Mansil	
11. Firth's Best	11. Firth-Sterling Invaro	11. Firth-Sterling Special Alloy
12. Special	12. Ketos	12. Liberty
13. Yellow Label		
14. Hess Special		
15. Double Special Tool		
16. Jessop's Best Cast Steel		
17. Special	17. Mangano	
18. Pompton Special	18. Oneida	18. Utica
19. W C S Extra	19. Constant	19. Alpha
20. Mecis		
21. Vasco Special	21. Vasco Non-Shrinkable Vasco Choice	21. Vasco Valutap
22. Special	22. Non-Shrinkable	22. Special W

AMERICAN TOOL STEELS

Steel Society, 1920

No.	REGULAR TOOL STEEL	TWIST DRILL STEEL	EXTRA TOOL STEEL
1.	Atlas Refined	Atlas Drill	Atlas X
2.	Bethlehem X C L	Bethlehem Twist Drill	Bethlehem XX
3.	Braeburn Standard		Braeburn Extra
4.	Comet	Twist Drill	Extra
5.	White Label No. 47	Twist Drill Red Label	Yellow Label No. 46
6.	Red Star	Colonial Superior	Colonial Extra
7.	Columbia Tool Steel	Columbia Superior	Columbia Extra
8.	Black Diamond Tool Champion Tool Crescent Tool Labelle Tool Standard Tool Howe-Brown Tool Singer Tool	Superior	Park-Silver Atha Extra Crescent Extra Labelle Extra Sanderson Extra Howe-Brown Extra Singer Extra
9.	Cyclops Cruc ble Cast		Cyclops Extra Tool
10.	Extra		Best
11.	Sterling		Firth-Sterling Extra
12.	Standard	Peerless	Extra Warranted
13.	Cream Label		Blue Label
14.	Hess Regular	Hess Drill	Hess Extra
15.	Extra Tool		Special Tool
17.	Standard	C F S	Extra
18.	Elba	Salish Arapho	Pompton
19.	W C S Regular		W C S Special
20.	Misco		Comis
21.	Vasco Latrobe		Vasco Electric
22.	Fort Pitt	Superior	Extra

No.	FAST FINISHING STEEL	HOT HEADING STEEL	HIGH SPEED STEEL
1.	Atlas XXX	Atlas Hot Die	L-XX
2.	Bethlehem Finishing	Bethlehem No. 58 Hot Work	Bethlehem Special High Speed
3.	Braeburn Alloy Finishing	Braeburn Alloy Hot Die	Braeburn High Speed Special
4.	Fast Finishing	T K	Star Zenith
5.	Class K No. 23	Otdi No. 9	Centurian Superior No. 1 Po-Kip-C No. 3
6.	Colonial Best Finishing	Colonial H. H. Die	Colonial High Speed
7.	Columbia Double Special	Columbia Phoenix	Columbia Clarite
8.	Park Double Special Atha Double Special Crescent Double Special Labelle Double Special Sanderson Double Special Howe-Brown Double Special Singer Double Special	Peerless "A"	Rex "A" Rex "AA" Rex "AAA" Atha Champion
9.	Cyclops Alloy A		Cyclops B 6 High Speed
10.	Fast Finishing	H. R. W.	Kutkwik
11.	Firth-Sterling R T	C. Y. W. Choice	Blue Chip
12.	Double Special	L. C. T. Alloy	Dreadnought
13.			Peerless
14.			Hess High Speed
15.			Bulldog International Service H. S.
16.			"Ark" Superior "Ark"
17.	Extra Special	Select	Electrite Uranium Electrite-Cobalt Electrite No. 1
18.	Iroquois Special	Mohawk Hot Work Die	Mohawk Extra
19.	Finishing Special Finishing	Special Bolt Die	Extra High Speed Extra High Speed Bits Double Extra High Speed Bits
20.			Simco
21.	Vasco Finishing	Vasco Marvel	Red Cut Superior Red Cut Superior Bits
22.	Regal No. 2		Wolfram

(*Continued from Page* 263)

ing engineering field with headquarters at the above address. He will continue his relation with the Whitney Mfg. Co., and other local interests. It is his intention to serve the smaller heat treating concern whose production is not sufficient to employ an expert metallurgist continuously. Mr. Rockwell graduated from the Sheffield Engineering School of Yale in 1907 and since that time has had wide metallurgical experience with eastern manufacturing concerns. During the war he was a captain in the Ordnance Corps and district metallurgist. At the present time he is chief chemist and metallurgist of the Whitney Mfg. Co., Hartford, Conn. He is a sustaining member of the American Society for Steel Treating. As a means of introducing himself to future clients, Mr. Rockwell has prepared an interesting 24-page booklet of questions and answers.

A study of the heat treatment of cast nonferrous alloys is to be made by the United States Bureau of Mines at the Pittsburgh experiment station. It is proposed to study the annealing of cast nonferrous alloys for the release of casting strains and the improvement of physical

(*Continued on Page* 35)

EMPLOYMENT SERVICE BUREAU

The employment service bureau is for all members of the Society. If you wish a position, your want ad will be printed at a charge of 50c each insertion in two issues of the Transactions.

This service is also for employers, whether you are members of the Society or not. If you will notify this department of the position you have open, your ad will be published at 50c per insertion in two issues of the Transactions. Fee must accompany copy.

Important Notice.

In addressing answers to advertisements on these pages, a stamped envelop containing your letter should be sent to AMERICAN SOCIETY FOR STEEL TREATING, 4600 Prospect Ave., Cleveland, O. It will be forwarded to the proper destination. It is necessary that letters should contain stamps for forwarding.

POSITIONS WANTED

SUPERINTENDENT OR FOREMAN—In heat treating department; 21 years experience in heat treating. Employed at present with large heat treating plant. Desire to make change. Salary desired $3000. Address 10-2.

TECHNICAL GRADUATE—As metallurgist or superintendent of heat treating department. Six years of extensive experience in chemical and physical testing and heat treatment of carbon and alloy steels in automobile and aeronautical motor plants. Best of references. Eastern location preferred. Salary desired $250 per month. Address 11-1.

METALLURGICAL ENGINEER—Columbia University graduate. 7 years experience in steel treating plant, also research department of large steel manufacturing company. Experience included laying out and overseeing commercial heat treatments of small automobile parts, and similar products, and testing of same; design and installation of heat treating equipment; installation and maintenance of pyrometers; research work on high tensile and shock resisting tructural steels, tool steels, magnet steels, etc.; micro examinations and microphotography; magnetic measurements; critical temperature measurements. Salary $200—$250 per month, depending on location. Address 10—3.

HEAT TREATING FOREMAN—Two years pyrometrical and heat treatment of gun forgings; one year heat treatment and physical testing of rolled bar stock, and simple analysis; 1½ years heat treatment, carburizing, and hardening of automobile forgings. Address 9-5.

FOREMAN: 30 years practical experience in heat treating, forging tool hardening, carbonizing. 5 years as foreman of heat treating. Location preferred in Pennsylvania, New Jersey, or Maryland. Salary desired $200 per month. Address 9-3.

CHEMIST OR HEAT TREATER—Technical graduate. Experience in chemical and physical testing, heat treating of steels, platinum metals and rare earths. Best of references. Reasonable salary. Address 12-10.

POSITION OPEN

A large spring manufacturer in the Middle West is looking for a young man with technical education, ingenious in the design and construction of new machinery, for position as assistant production manager. Prefers man with some knowledge of automobile spring making. Address: 10-5.

(*Continued from Page* 34)

properties. The investigation, which will have special reference to aluminum, will be conducted under a co-operative agreement with a commercial firm. Work on the investigation will be under the supervision of R. J. Anderson, metallurgist of the bureau of mines.

M. A. Green, for 10 years superintendent of branches and agencies of the Crucible Steel Co. of America, Pittsburgh, has become associated with the Newman-Andrew Co., 26 Cortlandt street, New York, as manager of its tool steel department. The company is the American representative of Jno. H. Andrew & Co., Ltd., Toledo Steel Works, Sheffield, England.

A 12-page bulletin describing gas burners and furnaces recently has been distributed by the Palo Co., 153-157 West 23rd street, New York. This pamphlet, which is illustrated, gives complete specifications for the various burners and furnaces.

According to an announcement just received, Henry Coe & Clerici, Genoa, Italy, merchants and agents for machinery, metals and scientific instruments, are closing their New York branch office at 68 Broad street, effective Nov. 30. This office was opened during the war when communication between America and Italy was uncertain. However, the activities of H. W. Mills, general manager, will continue from the head office in Genoa. The company lately has extended its chain of offices

(*Continued on Page* 36)

This qualification record will be printed in the "Men available" section of the Employment Bureau of the Transactions at a cost of 50c each insertion.

The money to cover this Charge should accompany this form.

QUALIFICATION RECORD—Strictly Confidential

Name

Address

No. of Years in Grammar School?	**Other Schools?**

Experience:

Wages Desired?	**Location Preferred**	**Kind of Position Desired**

(*Continued from Page* 35)

in Italy, having opened branches at Chiasso, Monza and Bolzaneto. At the latter place it has acquired extensive warehouse terminals.

The Wayne Oil Tank & Pump Co., Ft. Wayne, Ind., has just paid its ninety-first consecutive common stock dividend. Imprinted in large letters over the face of the paying checks was the phrase "91st Common Stock Dividend Payment." This company has been one of the few concerns whose business has not been affected seriously by present business conditions. During the past 18 months the company's business has been very good, and officials are confident that the record will be maintained.

M. K. Epstein, formerly located in Philadelphia, has moved to Hartford, Conn., where he will act as sales agent in the New England district for the Wilson-Maeulen Co., manufacturer of pyrometers and hardness testers, and Tate-Jones & Co., furnace engineers.

The Heppenstall Forge Co., Bridgeport, Conn., is changing all of the heating furnaces in its forge department from coal to oil-fired. A similar type of oil-fired furnace has been in use at the plant of the Heppenstall Forge & Knife Co., Pittsburgh, since April, and has proved so satisfactory that the change at Bridgeport was decided upon and the work is now in progress. The machine shop is working single time, and preparations are being made for putting the forge shop on a schedule of two to three days a week.

This request for workers will be printed in the Position Open section of the Employment Bureau of the Transactions at a cost of 50c each insertion. The money to cover this charge should accompany this form.

EMPLOYER'S REQUEST FOR WORKERS

Name of Employer

Address

Kind of Work

Experience and educational requirements:

Wages

Apply To

If you need men, fill out this blank and send to American Society for Steel Treating, 4600 Prospect Avenue, Cleveland, Ohio.